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PRELIMINARY REPORT of the Dutch Expedition to Karang Sago (Sumatra) for the Observation of the Total Solar Eclipse of May 1901

Before giving the preliminary account of our work, we shall recall in a few words the history of and the preparations for the expedition, as well in Holland as in the Dutch Indies

The first step towards the preparation of the expedition was taken on the 14th of October 1898, when, at the house of Prof J A C OUDEMANS and in the presence of Professors H G v D SANDE BAKHUYZEN and J C KAPTEYN, Prof A A NIJLAND called attention to the matter and at the same time intimated that already a considerable sum had been promised him for the purpose

As a consequence of this conference two meetings were held in the Trippenhuis on Jan 28 and April 22 1899, which were attended by the same four gentlemen The plan of a Dutch eclipse expedition appeared to be capable of execution, a rough estimate of the costs was made (*f* 50000 [1]) and the means to get the necessary money were discussed Prof v D SANDE BAKHUYZEN had already requested Dr J P v D STOK Director of the Royal Magnetical and Meteorological Observatory at Batavia and Major J J A MULLER, Commander of the Triangulation-brigade of the topographical service, also at Batavia, to provide information about the localities best situated for the observations and about the climatological conditions prevalent in these places

He had also addressed himself to His Excellency the Colonial Minister with the request to support the necessary investigations, and to promote the interests of the expeditions to be sent out, both from the Netherlands and from foreign countries

At the request of Mr NIJLAND it was further decided to call in

[1]) *f* 300 = 120 $ = 25 £ = 600   = 500 Mk

the aid of the Academy of Sciences Accordingly at the meeting of the Section of Sciences of May 1899, on the proposal of Mr v d Sande Bakhuyzen, an „Eclipse Committee" was nominated, consisting of the astronomical members of the Academy, Messrs H G v d Sande Bakhuyzen, J A C Oudemans, J C Kapteyn and E F v d Sande Bakhuyzen, and, as the physicist of the Committee, Prof W H Julius The Committee, excercising a granted right, assumed as further members Messrs J H Wilterdink and A A Nijland, and (on his arrival in Holland in June 1899) Mr J P v d Stok

The Committee called Mr H G v d Sande Bakhuijzen to the chair and elected Mr A A Nijland as their secretary In the years 1899, 1900 and 1901 nine meetings were held At the request of the Committee Messrs Julius, Wilterdink and Nijland were appointed by the Government to take charge of the observations in India, and Major J J A Muller undertook to act as chief of the expedition in India A detailed programme of the observations was next drawn up and the necessary instruments were planned and bought (See Proceedings Royal Academy Amsterdam, Vol III pages 529—543)

In the meantime the Eclipse-fund had increased to *f* 42000, of which no less than *f* 24000 had been contributed by private persons who took an interest in the expedition Further *f* 3000 was received from various scientific Societies, the Netherlands Government gave a subsidy of *f* 5000 and the Indian Government promised *f* 10000

It must also be mentioned that Messrs Julius, Kapteyn, van der Stok and Nijland composed a short pamphlet entitled „Directions for amateur observers", which was printed at Batavia and of which nearly 500 copies were distributed amongst the officials and inhabitants of the path of totality

In the meantime preparations for the expedition had been made in India by the Royal Physical Society of Batavia, at the request of the Government This Society nominated a Committee, consisting of Major Muller, Dr S Figee and Mr A C Zeeman, inspector of the „Gouvernementsmarine' etc, in order to continue in a more official manner the work begun by Messrs Muller and van der Stok This Committee published in 1900 a pamphlet under the title „Informations for observing parties and climatological conditions along the track of the moon's shadow", containing, as the result of the investigations which had also partly been made by Dr van der Stok, the data about the climate, the suitability and

the accessibility of many places near the central line of the eclipse, and of which 200 copies were distributed

The Committee received much support from the part of the Government of the Dutch Indies Not only was great pecuniary and other material aid provided, but the authorities also did their utmost to promote the interests of the expedition in every possible manner Thus, to mention only the most prominent matters, the co operation of several officers was granted *viz* captain WACKERS for making determinations of time and latitude in the eclipse-camp, lieutenant DE ROCHEMONT for the building of the camp, captain KERKHOFF for the observations of the flash-spectrum near the northern limit of totality, further the promise was given that a man-of-war would be stationed near the place of observation, so that the officers and crew might assist in the observations

Messrs MULLER and FIGEE personally inspected in two voyages (May and September 1900) the localities which appeared suitable for observations generally and for the erection of a Dutch eclipse-camp specially On their advice the Dutch expedition chose as observing station a locality near the kampong *Karang Sago* on the western coast of Sumatra

In January 1901 Dr FIGEE and Dr VAN BEMMELEN were authorised to take part in the expedition at the expense of the Observatory at Batavia, in order to make the necessary magnetical and meteorological observations during the eclipse

In the middle of March Mr DE ROCHEMONT arrived at the locality which was chosen for the erection of the eclipse-camp, in the time of three weeks he established there a very comfortably arranged camp Not to mention many coolies, the expedition disposed, for all kinds of preparatory work, of the services of twelve men of the corps of military engineers with two European and two Amboinese sergeants, two artisans of the same corps, a warrant-officer and a mandoer of the triangulation, a photographer and a mechanician There also was a post, and telegraph office on the spot

The members of the expedition appointed by the Eclipse-Committee, Messrs JULIUS, WILTERDINK and NIJLAND started on their voyage about the beginning of March At Genoa they met Mr J B HUBRECHT phil nat cand, who had been permitted to assist the expedition as a volunteer, and on board the „Koningin Regentes" they met eight American and English astronomers, who also intended to observe the eclipse in Sumatra We are specially indebted to the S S Company „Nederland" for the liberal arrange-

ments as to the conveyance of the observers and their instruments

On the sixth of April we arrived at Padang, whence, after some official calls, we started, on the 10th of April, together with Mr MULLER on our voyage to the camp by Government steamer The English expedition, which was going to *Aoer Gadang*, was also on board

On the 11th a start was made by the unpacking of the instruments (which appeared almost without exception to be in good condition), the surveying of the locality and the building of several (22) brick piers for the astronomical, physical, magnetical and meteorological instruments

Mr WACKERS had already started the determinations of time and latitude The latitude of the pillar of the Universal instrument was found to be 1° 19′ 27″ 5 South, the longitude was approximately determined at 100° 33′ 3 East of Greenwich

On the 23rd of April the last pillar was ready, the greater number of the instruments was already in position, protected by huts or sheds of bamboo and atap The long light-tight tube and hut for the 40-feet coronagraph were only ready on the 30th of April

The accompanying plan of part of the camp (Plate I) gives an idea of the relative positions of the instruments (See also Proceedings, Vol III, pages 529—543)

The adjustment of the instruments occupied the members of the expedition up to the last day The task of the other members was made much more difficult by the accident which happened to Mr WILTERDINK on the 3rd of May while occupied with Mr NIJLAND with the adjustment of the 10-inch coronagraph, he fell from a wooden scaffolding and broke his right radius Not only was the use of his hand strictly forbidden him, but he had to be transported to Padang for a few days, and though after his return he constantly assisted the other members with his advice, he was not able during the eclipse to take charge of one of the principal instruments

The erection of the magnetical and meteorological instruments was started on the 27th of April, under the direction of Mr VAN BEMMELEN, who arrived in the camp the day before On the 7th of May Dr S FIGEE arrived, accompanied by his son Mr TH FIGEE, volunteer assistant On the same day also Her Majesty's ironclad *Sumatra*, under temporary command of the lieutenant first class GELDERMAN, arrived on the road At the same time captain KERKHOFF visited the camp in order to study, under the direction of Messrs

JULIUS and NIJLAND, the objective grating spectrograph to be erected near the northern limit of totality

Messrs MULLER, WILTERDINK and NIJLAND had in the meantime drawn up a programme for the astronomical observations while Mr JULIUS did the same for the physical observations, so that on the 9th of May the practice drills with the officers and men of the *Sumatra* could begin

The work was divided as follows

Chronometers and *Siderostats* 5 assistants,
Large spectrograph Mr S FIGEE with 2 assistants,
Small spectrograph Mr DE ROCHEMONT with 6 assistants,
Spectroscope Mr HUBRECHT with 3 assistants,
Prismatic camera Mr NIJLAND with 4 assistants,
„40 *feet*" *coronagraph* Mr MULLER with 3 assistants,
„10 *inch*" *coronagraph* Mr WACKERS with 5 assistants,
Coronagraphs on polar axis midshipman BRANDT with 10 assistants,
Photometer Mr VAN BEMMELEN and midshipman BARON MACKAY with 2 assistants,
Actinometer Mr JULIUS with 4 assistants,
Polarimeter lieutenant V D ESCH with 3 assistants,
Pyrheliometer 2 assistants,
Cloud-theodolite lieutenant DE BRUYNE with 1 assistant,
Observations of wind 2 assistants,
Thermometers 4 assistants,
Atmospheric electricity Mr TH FIGEE,
Declinometer 2 assistants,
Drawings of corona midshipman BALSEM with 4 assistants,
Shadowbands and *further observations* midshipmen LANGELAAN and BUDDING with 14 assistants,
Look-out one assistant,

The total number of observers was thus 93, of whom 7 were officers and 68 non commissioned officers and men of the *Sumatra*

The uncertainty of the longitude of the place of observation and the experiences from former eclipses pointed to the desirability of deriving the last warning sign of „ready" not from the computation, but from the observations of the eclipse itself It was arranged that Mr MULLER should give this sign, when in the dark hut of the 40 feet coronagraph the crescent of the sun measured 45° According to computation this would occur 16s before the beginning of totality Moreover, the look-out was to watch the search light of the English man-of war *Pigmy*, stationed at *Aoer Gadang*, which light would, at our request, be screened off at the moment when totality began at that station

Computation had shown that the shadow would reach the Dutch eclipse camp about 15 seconds later

In the beginning of May the English astronomer NEWALL, who was stationed at *Sawah Loentoh*, sent notice that he had been informed by the *Nautical Almanac Office* at London that the duration of totality at *Karang Sago* would be $6^m\ 22^s$ instead of $6^m\ 32^s$ It was decided, to be on the safe side, to shut all cameras on the 380th second after the beginning of totality

The programme was for the greater part promptly executed on the 18th of May The sky was however rather heavily clouded, and the various observations and exposures have all experienced more or less the disturbing influence of the clouds Unfortunately, moreover, the nervousness of one of the assistants has made the results of the *small spectrograph* entirely useless

Owing to the clouds it was not possible to observe the sun's crescent of 45°, the last warning sign was given by the look-out Totality commenced $0^h 19^m 55^s$ (local time) and ended $0^h 26^m 16^s$, the duration therefore was $6^m 21^s$ The computation according to the Nautical Almanac gave $0^h 19^m 58^s$ for the beginning and $0^h 26^m 30^s$ for the end of totality, and therefore $6^m\ 32^s$ for the duration

Shadowbands have not been observed, besides *Venus* and *Mercury* only *Aldebaran* and a few stars in *Perseus* were visible As a consequence of the rather heavy clouds it was not nearly so dark during the eclipse as had been expected, so that the lamps which were kept ready have not been used

Immediately after the eclipse it was known that the *spectroscope* and the *small spectrograph* had given no results On developing the plates it also appeared that the exposure with the *large spectrograph* was an entire failure

Before mentioning the results of the astronomical and physical observations — the magnetical and meteorological observations are being discussed at Batavia — we shall finish the history of the expedition

On the 22nd of May Mr KERKHOFF arrived at the camp with the plate exposed by him at the northern limit of totality unfortunately this plate too brought a disappointment Apparently the instrument had been adjusted correctly, but by a misunderstanding, and in consequence of the fact that the northern limit was actually further North than had been expected according to the computation, the moment of observation was not well chosen the observer failed to get the phenomenon of the flash and photographed the

spectrum of the corona instead, for which the lens however was not rapid enough

On the 24th of May all instruments were packed and the expedition left the camp with the last of the 54 cases Mr MULLER undertook to have diapositives made and to send the cases to Holland Thanks to his care everything has arrived in good order

At Padang and Batavia Messrs MULLER, JULIUS, WILTERDINK and NIJLAND called on some high officials to express their thanks for the good care and many facilities which had been given to the expedition, on the 6th of June they had an audience of His Excellency the Governor-General at Buitenzorg, and were invited to dinner in the evening

On the 26th of June Mr JULIUS returned to Holland, at *Padang* he took charge of the negatives Messrs WILTERDINK and NIJLAND left Batavia on the 29th of June to return home via Japan and America Before they left they had an opportunity to inspect, at the Batavia Observatory, many drawings and descriptions which had been sent in by amateur observers, who had followed up the summoning contained in the above mentioned „Directions for amateur observers"

We now come to the principal contents of this report, *viz* the scientific results We will treat them in the following order

A The coronagraphs,
B The spectrographs,
C The physical observations,
D The amateur observations

A Coronagraphs

With regard to the photographs which were obtained of the corona, we are sorry to report that only the short exposures with slow instruments have given any decent result The long exposures and the exposures with rapid lenses have too much suffered from the general illumination of the sky and the illuminated clouds Moreover several plates are fogged

I Polar axis with 4 coronagraphs

These four coronagraphs were

a VOIGTLANDER *collinear* (the travelling camera R, equivalent focal length $f = 87$ cm $= 49\ a$),

a DALLMEYER *lens* (D, $f = 153$ cm $= 15\ a$),

a VOIGTLANDER *portrait objective* (V_1, $f = 38$ cm $= 3\ 6\ a$),

a VOIGTLÄNDER *euryscope* (V_2, $f = 85$ cm $= 8\ 1\ a$)

According to the programme six exposures were made, three of 1, 2 and 55 seconds respectively on plates „*Lumiere bleue*", and three of 178, 55 and 1 seconds on plates „*Lumière jaune*" During he long exposures a yellow light screen was used with the objectives V_1 en V_2

Exposure N[1] 1 is useless owing to the strong vibration or jolting of the apparatus the image has been displaced on some plates by as much as 4′

N[1] 6 has also failed owing to direct sunlight The long exposed plates all show the edge of the moon diffused, chiefly through irradiation and through the rather considerable motion of the moon (which amounts to $^1/_{110}$ diameter in 55^s and $^1/_{34}$ diameter in 178^s)

The camera *R*, which was only added at the last moment, evidently was not sharply focussed The only occasion to focus it was on the 17th of May, about eclipse-time

The *camera D* shows clouds on all plates, Plate N[1] 2 however is good, giving polar streamers to a distance of 10′, equatorial ones to 15′ from the moon's limb, N[1s] 3 and 4 are entirely fogged

The *camera* V_1 shows only clouds and fogging

The *camera* V_2 also shows clouds on all plates, the images are diffused by irradiation, Plate N[1] 3 is entirely fogged

The following summary gives for each of the 12 partly successful exposures the distance from the moon's limb to which the corona is visible, expressed in minutes of arc

	Nr 2	Nr 3	Nr 4	Nr 5
R	10	25	30	15
D	15	25	30	15
V	20	—	30	15

II „10 inch" coronagraph (Objective by STEINHEIL, *f = 342 cm = 13 3 a)*

Three exposures (of 2, 1 and 1 seconds respectively) have been taken on plates „*Lumiere jaune*", six (of 50, 5, 216, 5, 1 and 1 seconds respectively) on plates „*Lumiere bleue*"

The plates 1, 2 and 3 are fairly good though not perfectly sharp The corona can be traced to distances of 10′, 7′ 5 and 5 0 respectively from the moon's limb, with prominences and structural detail of inner corona N[1] 7 also shows, besides many clouds, a few

details of the polar streamers N^{rs} 8 and 9 however are entirely spoiled by clouds and by direct sunlight

The plates 4, 5 and 6 were fitted with rotating aluminium screens (BURCKHALTER apparatus) with a view to obtaining faint and bright parts of the corona on the same plate Three screens of different shapes had been selected In consequence of the cloudiness, it has unfortunately not been possible to bring the moon exactly on the centre of the plate, and to keep it there, so that the axis of rotation of the screens did not coincide with the centre of the moon's image

Nr 4 on one side shows details of the structure of the corona, Nr 6 shows the corona to a distance of 20′, Nr 5 to 15′ from the moon's limb, the rotating screen of this plate evidently was too small, so that the corona-streamers are lost in the completely fogged outer parts of the plate

III „40 *feet*" *coronagraph* (f = 11 77 *m* = 91 *a*)

This lens was most kindly lent us by the Superintendent of the U S Naval Observatory, Washington D C, to whom we tender most cordial thanks

The original size of the plates was 50 × 60 Having satisfied ourselves that no parts of the corona, nor any stars would be lost by the proceeding, we cut them down to 24 × 30 in order to ensure a safer transport During this operation nr 2 was broken into three pieces, without spoiling, however, the essential parts of the image

On Nr 1 ($^2/_3$ sec *Lumière bleue*) accidently three exposures of different durations have been impressed, some of the prominences have consequently gained in details, while others are smudged together and unfit for measurement

Nr 2 (20 sec *Lumière jaune*) shows very fine prominences and complicated details of the inner corona, which forms dome-shaped arcs round the prominences

Nr 3 (40 sec *Lumière bleue*) is nearly as good as the former

Nr 4 (180 sec *Lumière bleue*) This plate was fitted with a large rotating screen According to the programme a short time before the beginning of totality the mirror of the *coelostat* should be definitively adjusted so as to throw the image of the sun exactly on the centre of the plate Notwithstanding the aperture was greatly reduced, the sunlight was still so strong that Mr MULLER, fearing a fogging of the freely exposed plates, dared not admit the sunlight for more than a single moment The image of the sun apparently has fallen much too high on the plate, so that the centre

of rotation of the wing did not coincide with the centre of the moon's disc but with a point nearly on the moon's limb

Consequently this plate shows details of the corona on only one side, moreover the image is diffused in the direction from East to West, probably owing to an irregularity in the motion of the driving clock of the coelostat

Nr 5 (120 sec *Lumière jaune*) shows the same want of sharpness, which here also exists in the direction from North to South Prominences and „*Bailey's beads*" are elongated and useless

Nr 6 has little value owing to direct sunlight

B Spectrographs

I Three Prism Spectrograph (f = 7 7 *a*)

An exposure of 340 seconds on a panchromatic plate of LUMIÈRE has not given the slightest trace of the spectrum of the corona The width of the slit was $^1/_{40}$ mm On this plate and on the one exposed immediately afterwards air spectra of 20 to 60 sec exposure are very well measurable, some of them have even been over exposed Also the iron-spectrum given by a small coil and Leyden battery in 3 5 minutes is well measurable The plate is entirely fogged, which is evidently due to the development, since the edges, which were not exposed, are also fogged The plate cannot have been spoiled or stale, since proof plates taken from the same batch and exposed on the preceding days are very clearly developed, and are entirely clear up to the edges The matter is at present entirely inexplicable, since at all events the clouds should have given a spectrum

II Two Prism Spectrograph (f = 3 5 *a*)

The exposure with this instrument has entirely failed, the assistant charged with the control of the running plate having lost his presence of mind The plate shows very strongly the spectrum of the last crescent of the sun (exposure 5s on moving plate) It has however been stopped exactly in the moment when the first flash spectrum was to be impressed on it, though according to the programme it ought to have moved on for another 5 seconds The plate has then remained unmoved for some time and shows, adjacent to the above mentioned spectrum, a strongly over exposed spectrum, by which everything in the neighbourhood is fogged Next the plate ought to have been brought to its middle position for the exposure of the corona In this operation the lines of H and Ca have just been

impressed, and are visible on the plate On the middle of the plate however there is no trace of a spectrum, probably the plate has not been sufficiently displaced, and the corona has impressed itself on the strongly fogged part In this part there are a couple of continuous spectra, in which G is shown as a dark line, not however at the proper distance (the moon's diameter) from each other Of the second flash spectrum there is no trace

This plate also is not well developed The width of the slit was $^1/_{00}$ mm

III Spectroscope

In consequence of the cloudiness no trace of the spectrum of the corona could be observed with this instrument

IV Objective Grating Spectrograph

As has already been mentioned, the grating camera ($f = 16\,a$) which was mounted at the northern limit of the path of totality has given no results This is specially to be regretted since this locality was favoured by a very clear sky, and since, judging by the few crescents of the chromosphere which are shown on the spectrograms, the instrument has been correctly adjusted

V Prismatic Camera

This instrument (Cooke's triplet, $f = 260$ cm $= 17\,a$, two prisms of 45° with a total length of bases = 31 2 cm) was fed by a siderostat The plates (*Lumière panchromatique*) measured 16 × 16 cm, but might with advantage have been longer in the direction of the dispersion A solar spectrum, photographed by means of a temporarily mounted collimator, showed the lines sharp along the whole length of the spectrum The focussing was done the night before the eclipse by visual observation of the spectrum of *Arcturus*

According to the programme 5 exposures have been made of the first flash (plate 1), each of $^3/_4$ seconds by estimation, *viz* at the times $-\ 2^s$, 0^s, $+\ 2^s$, $+\ 5^s$ and $+\ 7^s$, where 0 is the zero of counting (It has appeared afterwards that the second contact, which was hardly visible through the clouds, has happened at the time $-\ 3^s$) After this four long exposures were taken (plates 2—5) by which it was hoped corona-rings would be photographed, these exposures lasted 5, 20, 190 and 60 seconds respectively Finally (plate 6) again 5 exposures of the flash were made, each of about $^3/_4$ seconds, at the times 2^s, 4^s, 6^s, 8^s and 10^s after third contact

On plate 1 only a small number (9) of chromosphere-crescents are visible, the second contact is badly shown owing to the clouds

On two of the four corona plates (Nrs 2 and 3) the ring λ 3987 is but faintly visible, these exposures naturally being much impaired by the disturbing influence of the clouds

The third contact appears to have occurred at a relatively clear moment Plate 6 shows a large number (150) of chromosphere-crescents between λ 3880 and λ 5000, in different phases of the flash phenomenon Especially the first exposure on this plate (2^s after third contact) is very rich in details The spectrum appears to be well focussed over its entire length

Prof W H JULIUS has already pointed out[1]) the very remarkable fact that every one of these chromosphere crescents is double, the distance of a pair varies from 0 7 to 1 6 *t m*

Though we have given much thought to the question, we are unable to ascribe this doubling to instrumental causes The distance of the components of a pair is in the mean 0 13 mm, i e about 11″ of arc The doubling, though different for different crescents and for different parts of the same crescent, has a very decided preference for one direction, inclining 9° (counted from N through E) to the parallel, or 15° to the horizontal, 22° to the ecliptic and 29° to the sun's equator

Though we do not wish to go too much into detail in this preliminary report, we may be permitted to mention that the most important instrumental causes which offer themselves for explanation of the observed doubling, are the following three

1st irregularities in the rate of the driving clock of the siderostat,

2nd a vibration of the prismatic camera or of its parts, and

3rd defective focussing

On closer examination it appears to us to be very improbable that any of these causes has been effective It is true, during the last exposures with the 40 feet coronagraph the clock of the siderostat seems to have performed badly, but *all* plates of the prismatic camera show the same doubling, as well the exposures of $^3/_4$ sec, as those of 60^s and 190^s, and both at the first and at the last flash Moreover there is no question of a diffused appearance of the images, but of a doubling, in a direction differing from that of the parallel

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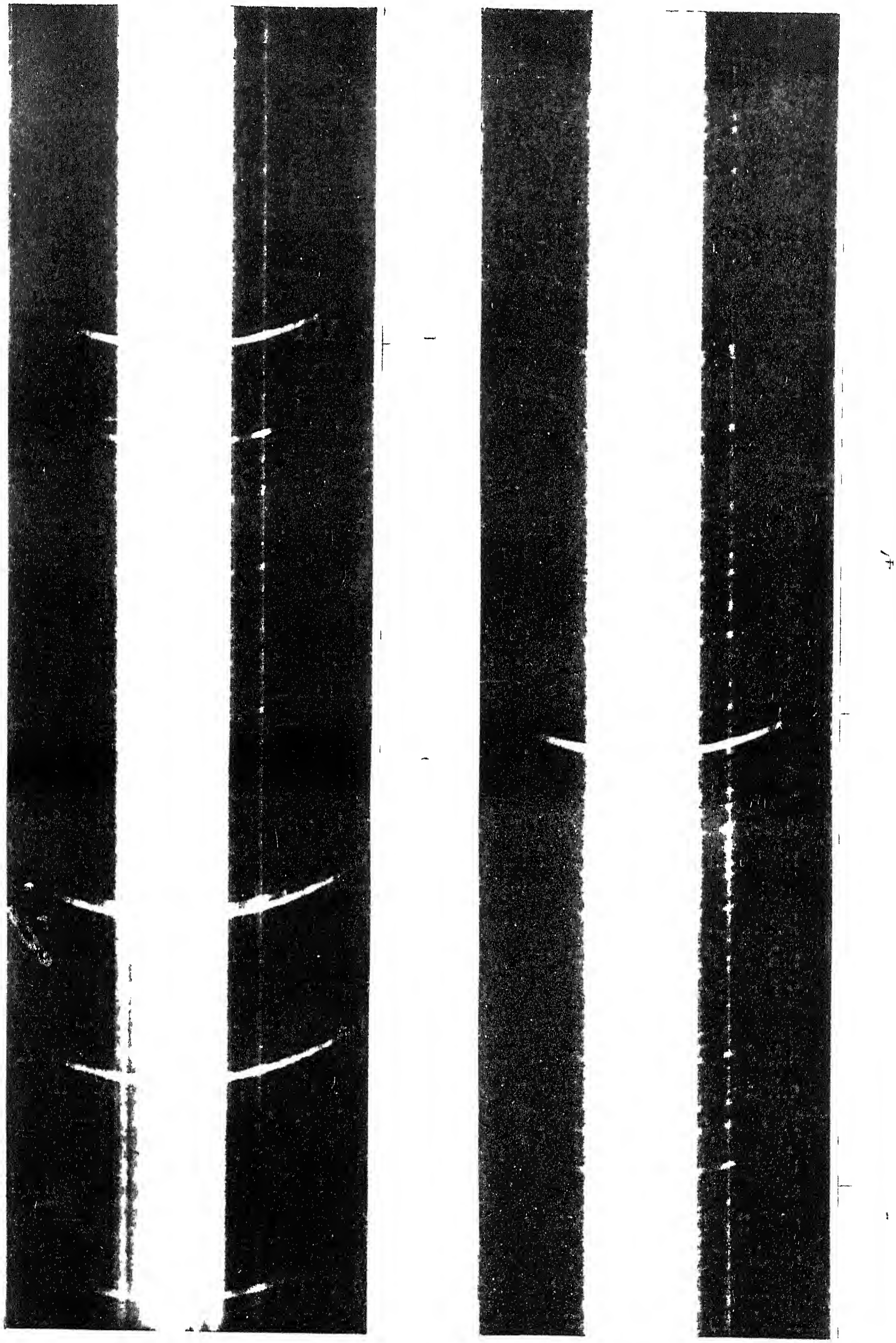
1) W H JULIUS *On the origin of double lines in the spectrum of the chromosphere, due to anomalous dispersion of the light from the photosphere* Proceedings Royal Ac Amsterdam Vol IV, p 195—203



The opening and closing of the shutter of the prismatic camera might have caused a vibration, probably chiefly in an horizontal plane, the fact however that the doubling is not constant in one and the same exposure, and on the other hand shows itself in the same manner both in the long and in the short exposures, makes also this explanation entirely unacceptable

No more can a considerable error of focussing be admitted, since on plate 6 lines are shown parallel to the direction of dispersion — Bailey's beads drawn out into lines by the prisms — which have a breadth of only 0 06 mm

Finally, as far as we can see, every instrumental explanation must fail through the fact that the distance of the components of a double crescent is very different for different crescents, while also the direction of the doubling and the relative intensity of the components is variable Moreover the corona-ring λ 3987 is, on plate 3, *sharply outlined* on the concave side (On plate 2 this ring is too faint to state the same fact with certainty) On comparing this outline with that of the neighbouring crescents of calcium (H and K), which are very distinctly double on the same plate, there can hardly remain any doubt as to the reality of the doubling of the chromo sphere-lines The light of the corona rings on the other hand appears to be more purely monochromatic

A reproduction of part of the first exposure on plate 6 is appended to this preliminary report (Plate II, enlargement about 4 times) in order to enable the reader to form an approximate idea of the character of the double lines The original negatives of course show many more details, such as Fraunhofer lines, etc , which would also be visible on a darker copy *This* copy has however purposely been kept fainter, in order to bring out clearly the almost linear flash spectrum formed by the lowest of „Bailey's beads" The wave lengths given in the figure are relative to this spectrum

Enlargements of the other exposures will be published afterwards

The doubling which was observed by us is also shown on previous flash-spectrograms, it appears however not to have drawn the attention of observers See e g the crescents of λ 4584, 4572, 4564, 4554, 4550, 4534, 4501, 4472, 4341 etc in the spectrograms which were obtained by Fowler with the „6 inch Prismatic Camera" during the eclipse of Jan 22 1898

When once the attention has been directed to this point, on these photographs too nearly all the crescents appear double, though less distinctly

The appended diagram (Plate III) gives a summary of the times of exposure of the coronagraphs and the prismatic camera

C Physical observations

I The polarization of the light of the corona

The aim of the observations of polarization was to measure the proportion of polarized light in as many well determined points of the corona as possible

The observations have been made in an excellent manner by lieutenant T J VAN DER ESCH and four assistents

Before the day of the eclipse the observers had repeatedly practised on an artificial corona, under circumstances as similar as possible to those which were expected during the eclipse This artificial corona gave in the telescope an image of about the same size as that of the real corona, its light was partly polarized in radial planes, while the proportion of polarized light could be altered at will, so that control was possible The observers got so well in practice that they were able to measure the proportion of polarized light on 12 arbitrarily selected points within 6 minutes, and to read off the coordinates of these points

A few minutes before the beginning of totality, as well as a few minutes after the end, the diffused light of the sky round the sun

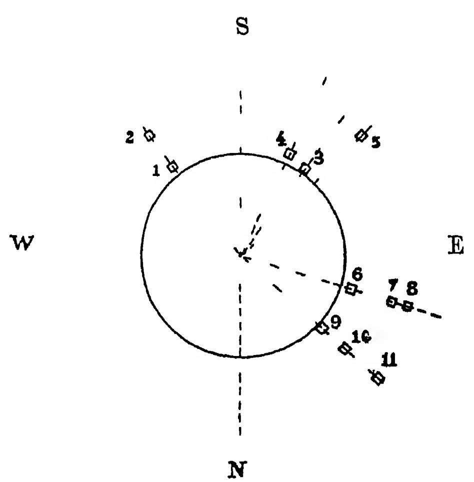
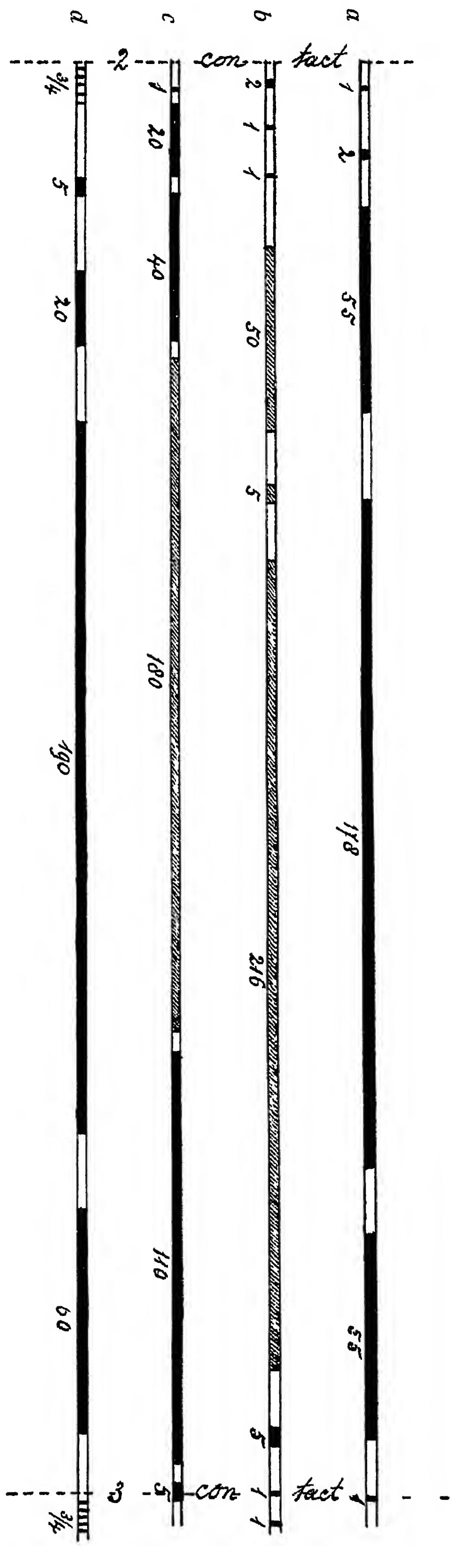


Fig 1

(at a distance of about one diameter from the sun's limb in the directions North, East, South and West) was analyzed to decide whether

Plate III

DIAGRAM OF EXPOSURES



a Small coronagraphs — *b* coronagraph f = 3,42 M — *c* coronagraph f = 11,77 M — *d* prismatic camera

The hatched spaces denote exposures in which BURCKHALTER screens were used

any atmospherical polarization was shown. This was however not found to any appreciable amount.

Mr VAN DER ESCH has succeeded during totality in making complete measures on 11 points of the corona. The result is given in the following table. The position angles are counted from North through East, the radius of the moon is 13,5 mm. Fig. 1 shows the positions of the points chosen. The image of the moon and the aperture of the diaphragm, (1.1 mm)^2, are drawn at their real size. The light admitted through this aperture was analyzed by a modified polarimeter of CORNU.

Nr	Position angle	Radius vector	Reading of analyzer α	Proportion of polarized light $\cos 2\alpha$
1	218,°5	15 mm	38°	0,242
2	218,5	20	34	0,375
3	145	14	37,5	0,259
4	155,5	15	43	0,070
5	136,5	22,5	45	0,000
6	73,5	15	38	0,242
7	73,5	20,5	42,2	0,098
8	73,5	22,5	45	0,000
9	48	14	38,2	0,237
10	48	18	34	0,375
11	48	24	44	0,035

It appears from these numbers that the light of the corona at a certain distance from the sun's limb is more strongly polarized than in the neighbourhood of that limb. At still greater distances the polarization decreases again. That the observation Nr 4 has given a smaller proportion of polarized light than Nr 3 must probably be explained by the fact that the pointing was made on one of the dark rifts.

All the observations having been made through clouds the question naturally arises how far the result of the observations can have been disturbed by this circumstance. It might be that a cloud or

haze, like a piece of frosted glass, had an appreciable depolarizing influence on the transmitted light

An investigation about the influence of haze on polarized light has been taken in hand in the physical laboratory at Utrecht, but has not yet been finished As the result of preliminary experiments we can only mention here that most probably the measures of the polarization of the light of the corona have only slightly been disturbed by the presence of clouds If the sky had been clear, the main results would have been the same

II *Heat-radiation of the corona*

In a much higher degree than the light rays the dark heat rays are intercepted by clouds and haze The conditions were thus very unfavourable for the measures of radiation, and this circumstance is so much the more to be regretted since the observations have shown that in clear weather the ratio between the total radiation of the corona and the total radiation of the uneclipsed sun would undoubtedly have been successfully determined

The method of observation was very simple A very sensitive small thermopile (consisting of 8 couples of alloys of bismuth whose total exposed surface occupied a circle of 5 mm diameter) was exposed without the intervention of either lenses or mirrors to the radiation of a circular patch of sky of 3° diameter

The apparatus was mounted parallactically and could easily be kept in such a direction that the eclipsed (or non-eclipsed) sun remained in the centre of the field of 3°

If we take as unit the radiation which will give a deviation of one scale-division, when the resistance in the circuit and the sensibility of the galvanometer have the same values which they actually had during the pointings on the corona, then the strongest radiation we observed during our stay in the camp is represented by the number 1941000 On clear days (e g on the 6th of May) the observations ran very regularly At 7^h58^m a m (in this section of the report we use *civil* time) of that day the radiation was 1457000, it increased with small oscillations caused by invisible haze to 1902000 at $12^h\ 0^m$

Not quite so regular but still very satisfactory were the readings on the fairly clear days of the 14^{th}, 15^{th} and 16^{th} of May On the 17^{th} no observations were made on account of the heavy clouds,

and on the morning of the 18th very discordant deviations of the galvanometer were obtained, clouds continually passing before the sun

During the time between the first and second contacts only 26 determinations of radiation were made at moments when the clouds were not too thick The direct radiation of the sun on the little thermopile at 10^h 46^m 10^s, (i e about 20^s before first contact) amounted to 1762000 The diminution which in the case of clear weather *could have been followed step by step*, now of course took place very irregularly At 12^h 18^m 54^s, i e 61^s before second contact we observed through the clouds an intensity of radiation of 604

After the beginning of totality the thermopile was directed in succession to four points of the sky, situated to the North, East, South and West of the sun, each at a distance of 3^0 from the disc, and between each of these exposures it was exposed to the corona All these fields were filled by clouds The readings of the galvanometer for the four fields round the corona showed irregular differences (varying between — 9 and + 1 scale-divisions) compared with the readings for the central field It was not possible to derive from the observations an estimation of the radiation of the corona, but the numbers obtained seem to point to the conclusion that the radiation of the corona cannot be much larger than the observed differences between the radiation of neighbouring groups of clouds The full moon would, in a clear sky, have given a deviation of 22 or 23 scale divisions, the radiation from the corona seems to be of the same order of magnitude

One thing is certain, viz that our results cannot be made to agree with the opinion of DESLANDRES that it is possible to measure the heat-radiation of the corona without an eclipse (C R CXXXI p 660)

After third contact the surroundings of the sun were comparatively clear for a few minutes, but soon afterwards the clouds came on again The observations were continued at intervals to 1^h 12^m when they were discontinued, the results being considered untrustworthy

The large influence of the clouds on the heat radiation is shown by the fact that 8 minutes before 2nd contact the transmitted radiation was 455, while 8 minutes after 3rd contact it amounted to 74300

Every precaution had of course been taken to make the instrument practically insensible for alterations of temperature in the neighbourhood Alterations within the above mentioned field of 3° diameter were the only ones that were recorded by the galvanometer

III Absolute amount of solar radiation

A number of observations were made with the electrical compensation-pyrheliometer of ÅNGSTROM on different dates and also on the date of the eclipse, but the great variability of the weather and the continual high percentage of aqueous vapour in the atmosphere are the reasons why the western coast of Sumatra is a very unfavourable region for obtaining good series of observations of absolute solar radiation

The number of gram calories per minute per square cm on May 18 at 10^h 45^m a m was

$$Q = 1{,}23$$

Very seldom a larger value than this was found during any of the days preceding the eclipse, only once we found 1,35

At Teneriffe, at a small elevation above the level of the sea ÅNGSTROM found $Q = 1{,}37$, the sun's altitude being 70° It appears therefore that even on clear days in the coast-region where we stayed the heat-radiation is to a considerable extent absorbed by the atmosphere

We intended to make observations with the pyrheliometer during the partial phase of the eclipse so long as the heat-radiation would be sufficiently intense, in order to check the simultaneous results of the thermopile, and to convert these latter into absolute measure This end has however not been attained, owing to the exceeding variability of the radiation the pyrheliometer ceased to give reliable results soon after first contract

D Amateur observations

The „Directions for amateur observers" contained a recommendation for the following operations

I drawings of the corona,

II photographs of the corona,

III photographs of the landscape during the different phases of the eclipse,

IV observations of „shadowbands",

V meteorological observations,

VI further observations about

a the colour of the corona,

b the visibility of the corona before and after totality,

c the colour of landscape and sky,

d the visibility of stars

Limiting ourselves in this preliminary report to those points from which possibly a result of some value can be derived, we will omit the observations mentioned sub III and VI

I The drawings of the corona, of which a fairly large number (39) has been sent in, show much smaller discrepancies than have generally been recorded before (See e g ABBE's report of the total eclipse of July 1878) This fact must be ascribed to the care with which evidently the observations have been prepared

Probably the policy recommended in the „Directions", and which has been followed up by several observers, of making one person responsible for only one quadrant, or one half of the corona, has done much towards securing a good result, while also the long duration of totality (maximum $6^m 4$) naturally was a very favourable circumstance

In the following table the localities have been arranged from West to East

LOCALITY	Number of drawings of corona	Quality	Remarks
Fort de Kock	1 whole and 8 quadr	fair	
Padang Pandjang	2 〃 8 〃	good	
Karang Sago	1 〃 〃 4 〃	fair	partly clouded
Pajacombo	5 〃	fair	
Moeara Tambesi	1 〃	useless	
Blinjoe	1 〃 and 2 halves	very good	
Pontianak	1 〃 〃 4 quadr	very good	
Moeara Djawa	〃	fair	
Samarinda	9 〃	good	cirrus clouds A screen has been used to cover the bright parts of the corona
Saparoea	2 〃 and 8 quadr	very good	
Banda	1 〃 , 8 〃	fair	
Gisser	3 〃	fair	
Total	39 drawing		

These 39 drawings of the corona provide, in our opinion, very useful data for a definitive picture of the corona independent of the photographs, and which may be a real contribution to our knowledge of the corona of 1901

II Of the 69 photographs of the corona which have been sent in, made on all sorts of plates with all sorts of cameras, 15 appear to be practically useless The quality of the others is given in the following table, where

1 means all but useless
2 „ fair
3 „ good
4 „ very good
5 „ excellent

The second column gives the diameter of the image of the sun in millimeters

LOCALITY	⊙	Quality					Total	Remarks
		1	2	3	4	5		
Padang	5		2	3	1		6	
Fort de Kock	1	1	1				2	
"	$1^1/_4$	1	1				2	
"	$3^1/_2$				1	5	6	
Djambi	2	1					1	
Blinjoe	$2^1/$		1			5	6	
"	$2^1/_2$		2		4		6	film
Pontianak	2				1		1	
Samarinda	$1^1/_2$	1			1		2	
Donggala	$1^1/_2$	3	2	1				
Saparoea	$3^1/_2$			2	3	1	6	
Banda	$1^1/_2$					4	4	
"	$2^1/_2$		1			2	3	
?	4				3		3	
Total		7	10	6	14	17	54	

Further informations must still be provided about the name of the locality denoted by ? The three photographs sent in from that

locality would have been excellent if not by an unjudicious treatment the sensitive film had been damaged

IV Reports about observations of shadowbands have come in from the following localities, again arranged from West to East A + sign in the 2nd, 3rd, 4th, 5th and 6th columns respectively means that the shadowbands have been observed on an horizontal plane, on a vertical plane, before totality, after totality, and that details are given about their motion The 7th column gives some remarks about the cloudiness

LOCALITY	hor	vert	before	after	motion	Cloudiness
Fort de Kock	+	+	+	+	+	
Padang Pandjang	+	—	+	+	+	
Karang Sago	—	—	—	—	—	partly clouded
Pajacombo	+	+	+	—	—	
Moeara Tambesi	—	—	—	—	—	lightly clouded
Djambi	—	—	—	—	—	half 〃
Blinjoe	+	+	+	+	+	
Pontianak	+	—	+	—	—	
Boentok	—	—	—	—	—	
Moeara Teweh	+	—	+	—	+	
Moeara Djawa	—	—	—	—	—	lightly clouded
Samarinda	+	+	+	+	+	〃 〃
Donggala	+	—	+	+	+	
Posso	—	—	—	—	—	cloudy
Saparoea	+	+	+	+	+	
Banda	+	—	+	+	+	
Gisser	—	—	—	—	—	clear

We further append a list of the localities mentioned in this account, their co ordinates and the duration of totality

LOCALITY	Long E	Lat S	Duration	LOCALITY	Long E	Lat S	Duration
Banda	129° 9	4 5	3m 0	Moeara Tambe i	103 1	1° 4	5m 1
Blinjoe	105 7	1° 6	2m 0	» Teweh	114° 9	1° 0	5m 7
Boentok	114° 8	1° 1	5m 7	Padang	100° 3	1° 3	6m 2
Djambi	103° 6	1° 6	4m 3	Padang Pandjang	100° 4	0 5	4m 3
Donggala	119° 7	0° 7	3m 6	Pajacombo	100 6	0° 2	2m 6
Fort de Kock	100° 4	0° 3	2m 8	Pontianak	109° 3	0° 0	5m 7
Gisser	130° 9	3 9	4m 4	Posso	120° 8	1° 3	5m 1
Karang Sago	100° 5	1° 3	6m 4	Samarinda	117° 3	0 5	4m 8
Moeara Djawa	117° 2	0° 9	5m 5	Saparoea	128 6	3° 6	4m 4

V The meteorological observations which have been sent in, will be discussed at Batavia

Utrecht
Leiden March 1902

W H JULIUS
J H WILTERDINK
A A NIJLAND

TOTAL ECLIPSE OF THE SUN,

May 18, 1901

Reports on the Dutch Expedition

TO

KARANG SAGO SUMATRA

Published by the Eclipse Committee of the Royal Academy,

Amsterdam

N⁰ 1 GENERAL ACCOUNT

BY

Dr A A NIJLAND

TOTAL ECLIPSE OF THE SUN, May 18, 1901

Reports on the Dutch Expedition to Karang Sago, Sumatra

BY

DR A A NIJLAND

On October 14, 1898 the writer visited Mr P W JANSSEN, of Amsterdam, to call in his financial aid on behalf of a Dutch expedition to India for the observation of the total solar eclipse of May 1901 Mr JANSSEN, formerly Director of the *Deli Maatschappij*, is very well known, not only in Amsterdam, but all over Holland, for his philanthropy and his liberality towards artistic and scientific affairs He immediately took a lively interest in this National scientific enterprise , he at once gave a considerable sum to inaugurate an *Eclipse Fund* with, and thus made it possible to take a first step towards the preparation of the expedition on October 28, at a dinner given by Prof Dr J A C OUDEMANS, the writer suggested the plan of a Dutch Eclipse expedition to a few astronomers, who were amongst the guests

As a consequence of this suggestion, three preliminary meetings were held in the *Trippenhuis* at Amsterdam, which were attended by Prof Dr J A C OUDEMANS of Utrecht, Prof Dr H G V D SANDE BAKHUYZEN of Leiden, Prof Dr J C KAPTEYN of Groningen and the writer

At the first conference (1898 Nov 26) the plan was provisorily discussed and proved capable of execution Information about the most suitable methods of observation shall be gathered from various experienced eclipse observers Special attention shall be paid to the weather conditions along the shadow path, as not only a Dutch

expedition is to be prepared, but also many foreign eclipse observers may be supposed to come to India for this remarkable eclipse, who ought to be able to get full information about this essential point.

At the second meeting (1899 Jan. 28) letters were read, containing the views and suggestions of several distinguished astronomers (Prof. C. A. YOUNG, Prof. G. E. HALE, Prof. H. C. VOGEL) on eclipse matters and the best way to take advantage of the very long duration of this eclipse ($6^m.5$). A preliminary programme of observations was drawn up, a rough estimate of the costs was made (*f* 50 000 [1])) and the means to get the necessary money were discussed. Mr. v. d. SANDE BAKHUYZEN had already requested Dr. J. P. v. d. STOK, Director of the *Magnetisch Meteorologisch Observatorium* at Batavia and Major J. J. A. MULLER, Commander of the *Triangulatie brigade van den topografischen dienst*, also at Batavia, to provide information about the localities best situated for the observations and about the climatological conditions prevalent in these places.

He had also addressed himself to His Excellency the Colonial Minister with the request to support the necessary investigations, and to promote the interests of the expeditions to be sent out, both from the Netherlands and from foreign countries.

At the third conference (1899 April 22) the writer reported that he had succeeded in increasing the Eclipse Fund to nearly *f* 23 000, thanks specially to the liberality of Baron G. ROSENTHAL of Amsterdam, who contributed a considerable sum. At the writer's request it was decided to call in the aid of the *Koninklijke Akademie van Wetenschappen* (Academy of Sciences) at Amsterdam. Accordingly, at the meeting of the *Natuurkundige afdeeling* (Physical section) of May 1899, on the proposal of Mr. v. d. SANDE BAKHUYZEN, an „*Eclips-Commissie*" was nominated, consisting of the astronomical members of the Academy, Messrs. H. G. v. d. SANDE BAKHUYZEN, J. A. C. OUDEMANS, J. C. KAPTEYN and Dr. E. F. v. d. SANDE BAKHUYZEN (of the Leyden Observatory), and, as the physicist of the Committee, Prof. Dr. W. H. JULIUS, of Utrecht.

The E. C. was authorized to assume as further members Dr. J. H. WILTERDINK (of the Leyden Observatory) and the writer. In June 1899 Dr. J. P. v. d. STOK, who had in the meanwhile resigned the Directorate of the Batavia Magnetical and Meteorological Observatory, came to Holland and also joined the E. C.

In the years 1899, 1900 and 1901 nine meetings were held. I

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1) *f* 300 = 120 \$ = 25 £ = 600 frs = 500 Mk.

shall give a short chronological account of the proceedings of these meetings and of what has been further done in the interest of the expedition

At the first meeting of the E C, 1899 July 25, Mr H G v D S BAKHUYZEN was called to the Chair, the writer was requested to act as Secretary and Treasurer The principles on which a programme of observation should be based, were discussed in the first place the spectrum of the corona and of the sun's limb (flash spectrum) shall be studied, second in order of importance will be the photography of the corona, in the third place attention shall be paid to other astronomical, physical and meteorological phenomena Four subcommittees were nominated to work out these principles Messrs KAPTEYN and WILTERDINK will report on the spectrum of the corona, Mr JULIUS and the writer on the spectrum of the flash, Messrs H G and E F v D S BAKHUYZEN on the photography of the corona, Messrs VAN DER STOK and E F v D S BAKHUYZEN on various astronomical, physical and meteorological observations

Mr WILTERDINK and the writer will travel to India to take charge of the observations, whereas Major MULLER, of Batavia, will be requested to act as chief of the expedition in India

Finally, the President reported that at the request of the Government, His Excellency the *Gouverneur Generaal van Nederlandsch Indie* had charged the *Koninklijke Natuurkundige Vereeniging* (Royal Physical Society) at Batavia with the preparatives of the expedition in India This Society nominated (May 1899) an Indian Eclipse Committee, consisting of Mr MULLER, Dr S FIGEE, who had succeeded Mr VAN DER STOK as Director of the Batavia Observatory and Mr A C ZEEMAN, Inspector of the *Gouvernementsmarine* etc

At the second meeting of the E C (1900 Jan 7) three reports were read, by the subcommittees afore mentioned, viz

1st on the spectrum of the corona,

2nd on the spectrum of the flash,

3rd on the photography of the corona

The spectrographical equipment shall consist of

a 6 inch Prismatic Camera and a slit spectrograph with moderate dispersion (2 compound prisms) for the general study of the spectrum of the corona and for the flash-spectrum,

a slit spectrograph of great dispersion (3 compound prisms) for the study of one particular wavelength of the coronal spectrum at the E and W limbs of the sun's disc

These instruments shall be fed by two double polar siderostats (diameter of the mirrors 20 cm).

Mr WILTERDINK and the writer were authorized to enter into negotiations with P GAUTIER (Paris) on the siderostats and with TH COOKE and sons (York) on the Prismatic Camera. They shall go to Potsdam, in order to consult Prof J SCHEINER on the construction of the slit spectrographs, and to visit TOEPFFER's workshops.

Two objective glasses were stated to be available for the construction of coronagraphs: a 10″ STEINHEIL lens ($a = 26$ cm, $f = 342$ cm) belonging to the Utrecht Observatory, and a 4″ DALLMEYER lens ($a = 10$ cm, $f = 153$ cm) belonging to *Teyler's Museum* in Haarlem; these lenses shall be mounted on polar axes. A BURCKHALTER apparatus (rotating „controlling" diaphragm immediately in front of the plate) shall be used in connection with the 10″ coronagraph.

From Jan 21 to 26 1900, Mr WILTERDINK and the writer visited VOIGTLÄNDER's shops at Brunswick and those of TOEPFFER at Potsdam, in order to discuss the optical and the mechanical parts of the slit-spectrographs. They enjoyed a hearty and hospitable welcome and obtained many valuable suggestions from Prof J SCHEINER.

At the third meeting of the E C, 1900 Jan 27 a report of the Potsdam trip was read; in agreement with the conclusions of this report the three prism spectrograph shall be constructed so as to suit best the study of the blue line λ 4233, this line promising better results than the chief coronal line λ 5303.

A COOKE's direct vision spectroscope belonging to the Utrecht Observatory shall further be mounted on a 4″ STEINHEIL telescope, to visually observe the flash and the green coronal line.

Mr WILTERDINK and the writer were authorized to travel to America, in order to study American methods of eclipse observing and at the same time to experience the emotions of their first total eclipse (1900 May 28).

Accordingly, from May 3 to July 2 1900, they visited the U S of America and inspected several eclipse camps along the shadow path. At Wadesboro' N C they visited Prof YOUNG's camp and the combined camps of the Yerkes Observatory (Prof HALE, in charge, Prof BARNARD and others) and of the *Smithsonian Institution*, under Prof ABBOT. At Barnesville, Ga they met Prof LORD and the Eclipse party of the U S Naval Observatory under Prof BROWN. At Thomaston, Ga finally they spent four days in the Lick

Observatory camp (Prof. CAMPBELL in charge, Prof. PERRINE, and others).

Everywhere they met with a most cordial and friendly welcome. Besides, they were extremely happy to be allowed by Prof. CAMPBELL to take part in the eclipse work not only as interested spectators but as astronomers. They assisted at and went through the regular practice drills at the Lick camp. The advantage to be gained therefrom for preparing them for similar work at the coming eclipse must be evident.

When the eclipse was successfully observed, Mr. WILTERDINK and the writer visited several American observatories (Yerkes, Princeton, Yale, Harvard, Washburn, Dearborn and the Naval Observatory) partly to see some of the results obtained, and to take advantage of the hints suggested by this newly observed eclipse, partly merely to become personally acquainted with American astronomers and observatories.

They express their most cordial thanks to their American fellow-astronomers, Professors YOUNG, HALE, PICKERING and CREW for their kind hospitality. Last but not least, at the initiative of Prof. BROWN, Captain DAVIS, Superintendent of the U. S. Naval Observatory at Washington, D. C., lent them one of the seven 40 foot lenses (a = 13 cm., f = 1177 cm.) purposely made for the Venus transit of 1874, and thus completed, in a most satisfactory way the instrumental outfit of the Dutch expedition.

At the fourth meeting of the E. C., 1900 Aug. 3, the President reported, that the Eclipse Fund had increased again, thanks to several liberal gifts from private persons and Scientific Societies, and thanks principally to a subsidy from the Netherlands Government and another from the Indian Government. With the most valuable American 40 foot lens, two rapid lenses, to be bought at VOIGTLANDER's, and an ordinary camera from ERNEMANN with a VOIGTLANDER collinear, there will be six coronagraphs, presenting a wide range in f/a (viz. from 3.6 to 91). Mr. JULIUS was requested to join the expedition as a physical observer. The *Indian Eclipse Committee* (to be mentioned hereafter, see p. 10) shall be requested to provide a professional photographer and a mechanic, and to enter into negotiations with the Indian Government in order to have a man-of-war and a Government steamer placed at our disposal.

At the fifth meeting of the E. C., (1900 Sept. 8), it appeared from a letter from Mr. MULLER, that the I. E. C. had already

taken many steps (to be mentioned hereafter) towards the preparation of the expedition. Thus e. g. they had anticipated the wishes of the Home Committee in reference to a man of war and a Government steamer.

As a consequence of a report read by Messrs. v. d. STOK and E. F. v. d. S. BAKHUYZEN on physical observations (see p. 5) the instrumental equipment shall be completed by a WEBER photometer, a polarimeter and two pyrheliometers, viz. an ANGSTROM compensation pyrheliometer for the absolute amount of the coronal heat radiation, and a heat actinometer constructed without mirror or lens, which was devised by Mr. JULIUS, so as to be capable of registering step by step the heat radiation of the non eclipsed and eclipsed sun. For purely meteorological observations a consultation shall be held with Mr. FIGEE at Batavia.

At the sixth meeting of the E. C. (1900 Nov. 24) the locality for the erection of the Dutch eclipse camp was definitively chosen, in accordance with the advice of the I. E. C.: a piece of sandy soil, at the West coast of Sumatra, on the sea shore, between the *kampongs Karang Sago* and *Salido*, on the highway from *Taroesan Bay* to *Painan*. A letter of Mr. MULLER was read reporting on various important steps (see p. 12) taken by the I. E. C. Thirty sets of 24 large scale topographical maps of the path of totality have been received from the Indian Government: these maps will be distributed amongst such foreign observatories and astronomers as may be supposed to plan an expedition to India. The Batavia Committee published a paper (see p. 11) entitled „Informations for observing parties and climatological conditions along the track of the moon's shadow."

It is decided that one of the double polar siderostats will carry a coelostat mirror (diameter 25 cm.) to provide a beam of corona-light for the American 5 inch lens, which is to be placed in front of a horizontal tube, at the other end of which a frame carrying the plates shall be erected in a light tight hut. A small grating camera shall be mounted near the Northern limit of totality, in order to photograph the flash spectrum under special conditions.

At the seventh conference of the E. C. (1901 Febr. 23) the President read a detailed description of the instruments available, for which the reader may be referred to the Proceedings of the Royal Academy at Amsterdam, Vol. III, pages 529—543.

A paper entitled „*Korte Handleiding voor het verrichten van eenvoudige waarnemingen*", containing directions and suggestions for

amateur eclipse observers, has been composed by Messrs JULIUS, KAPTEYN, VAN DER STOK and the writer It was sent (Jan 1901) to Batavia, printed at the „*Landsdrukkerij*" (Government Printing Office) and distributed in 500 copies amongst the officials and inhabitants of the path of totality, and amongst the officers of several men-of war and trading vessels The *Korte Handleiding* treated various subjects, viz

I drawings of the corona ,
II photographs of the corona ,
III photographs of the landscape during the different phases of the eclipse ,
IV observations of „shadow bands" ,
V meteorological observations ,
VI further observations about
a the colour of the corona ,
b the visibility of the corona before and after totality ,
c the colour of landscape and sky ,
d the visibility of stars

Messrs JULIUS, VAN DER STOK and the writer have drawn up a programme for the times of exposure with the various coronagraphs Very short and very long exposures are planned the latter shall be handicapped by a lightfilter or by a rotating BURCKHALTER diaphragm The four camera's that will be attached to one polar axis shall have identical exposures Reduced to $f/_a = 15$ and to the sensitiveness of plates *Lumiere bleue*, the 39 exposures to be made with the six coronagraphs (see p 7) will range from $\frac{1}{60}$ and $\frac{1}{20}$ seconds to 200, 240, 272 and even 1350 seconds , the shortest exposure will be taken with the American 5 inch lens ($f/_a = 91$) on *Lumiere bleue*, the longest one with a very rapid VOIGTLANDER portrait objective ($f/_a = 3\ 6$) on *Lumiere jaune*, using a yellow lightscreen

The members of the expedition appointed by the Eclipse Committee, Messrs JULIUS, WILTERDINK and the writer started on their voyage about the beginning of March, Mr WILTERDINK travelling *via* Paris in order to look into the process of the silvering of glass mirrors at GAUTIER's shops, and to buy the necessary ingredients The expedition has got an official character by a Government appointment, so that the journey will be made *on H M's Service* At Genoa they met Mr J B HUBRECHT, phil nat cand (Utrecht), who had been permitted to assist the expedition as a volunteer

The SS *Koningin Regentes* left Genoa on March 9 On board

were several American and English astronomers, who also intended to observe the eclipse in Sumatra, viz Mrs and Mr NEWALL (from Cambridge, England), Mr DYSON from the Greenwich Observatory, with Mr ATKINSON as a volunteer assistant, Prof BURTON and Messrs HOSMER, MATTHES and SMITH from the Massachusetts Institute of Technology at Boston

The voyage was very pleasant, much attention being paid to various astronomical observations, the „green flash" at sunrise and sunset, Nova Persei, and the constellations of the southern hemisphere, Argo Navis, Crux etc At the last dinner on board, the day before our arrival in Padang, many hearty toasts were proposed, expressing best wishes for the success of the American, English and Dutch expeditions

On April 6 we arrived at *Emmahaven*, the harbour of *Padang*, and there met Mr MULLER

Before giving a further account of our *faits et gestes*, I shall first mention the preparation of the expedition in India

As far back as October 1898 the writer, in a private letter to Dr W VAN BEMMELEN, temporary Subdirector of the Magnetical and Meteorological Observatory at Batavia, pointed out the importance of the coming eclipse of May 1901 and suggested to him the desirability of weather observations along the path of the Moon's shadow, to be made in May 1899 and 1900 In a more official manner, as already mentioned (p 4), Mr H G V D S BAKHUYZEN wrote about the same matter to Mr V D STOK and Mr MULLER, and these letters may be regarded as the first steps towards the preparation of the eclipse work in India

See p 5 of this *Account* for the origin (May 1899) of the *Indian Eclipse Committee*, consisting of Messrs MULLER, FIGEE and ZEEMAN This I E C at once set to work in numerous localities along the path of totality a weather service was established, in order to obtain the necessary information about the climatological conditions

The weather observers were instructed to note at the hours about noon

1st the cloudiness of the sky,

2nd the kind of clouds,

3rd whether the sun was visible at the hour of observation,

4th whether it rained at the same moment

The *Natuurkundige Vereeniging* also gave a most valuable financial aid it contributed a liberal sum to the Eclipse Fund and, thanks to its intercession, moreover, a sum of *f* 10 000 of the Indian

budget, granted annually for scientific travels, was given to the expedition

The weather observations, made chiefly in April, May and June 1900, were worked out and the results were published (Aug 1900), at the Government's expense, in the little pamphlet already mentioned (p 8) *Informations for observing parties and climatological conditions along the track of the moon's shadow*, containing the data about the climate, the suitability and the accessibility of many places near the central line of the eclipse The weather chances (probability of rain and cloudiness) were derived from the amateur observations, above mentioned, from the numerous data to be found in „*Observations made at the Royal Magnetical and Meteorological Observatory at Batavia*", vols I—XXI, and from a few publications by Mr v D STOK on the climate of the Malay Archipelago

The paper further contains a map, many general practical hints and suggestions for observers, and all kinds of valuable information about different places, suitably situated at the West coast of Sumatra, on Singkep and the islands of the Lingga group, on Borneo, Celebes and the Moluccoes In the preparation Mr v D STOK took a great share up to his departure from India (June 1899) Of this publication 200 copies were distributed among many observatories and astronomers in Europe, America, British India, Australasia and Japan

In May 1900 Messrs MULLER and FIGEE, again at the Government's expense, personally inspected several localities on the shadow path, which appeared suitable for observations generally, and for the erection of a Dutch eclipse camp especially

From what has been said it may appear that the Indian Government did its utmost to further the interests of the expedition in every possible manner In fact every pecuniary and material aid was provided I have already mentioned (p 10) the subsidy of *f* 10 000 and the very liberal arrangements concerning the printing of the „*Informations* " and the payment of the travels of the I E C But at the suggestion of this Committee, and of Mr MULLER especially who proved also here to be *the right man in the right place*, the following very liberal facilities were allowed, viz

Freedom of postage was granted for eclipse matters

Permission was given that a regular Post and Telegraph Office should be stationed at the eclipse camp

Thirty sets (see p 8) of 24 very elaborate and accurate topographical maps of Sumatra's West coast and of Borneo — a value of

nearly *f* 2000— were put at the I E C's disposal, to be distributed to such observatories and astronomers as might be desirous to come to India to observe the eclipse

The Government steamer *Condor* was placed at the service of the Committee, on board this steamer Messrs MULLER and FIGEE started, Sept 1900, on another inspection voyage to the West coast of Sumatra The result of this second voyage was the definitive choice (see p 8) of the locality where a Dutch eclipse camp should be erected a site near the *kampong Karang Sago*

In Nov 1900 freedom of customs was granted, for eclipse instruments, not only to Dutch but also to foreign observing parties (Astron Nachr N° 3688, Nature N° 1632)

Dutch and foreign eclipse observers enjoyed free passage on all the lines of the *Staatsspoorwegen* (railways) *ter Sumatra's Westkust*

Most valuable assistance was obtained from the Naval and War Departments

The military topographical service lent four chronometers, a 10 inch PISTOR and MARTINS *Universal Instrument* and other instruments

The *Militaire Administratie* lent, free of any charge, everything in the line of furniture and all other requisites required for the outfit of the eclipse camp

The *Genie* (Military Engineers) gave a number of carpenter's, brick layer's and *bamboe* worker's tools, Norton pumps, a fire engine etc

The following gentlemen were directed to the camp to assist in the preparation and the observation of the eclipse, viz

Captain L H F WACKERS for determining the latitude and the local time,

Lieutenant — since May 1901 captain — E J DE ROCHEMONT for the building of the camp He was in command — not to mention a few hundred coolies — of twelve men of the corps of Military Engineers, with two European and two Amboinese sergeants, a carpenter and a brick layer of the same corps,

Captain J M KERKHOFF for the observation of the flash spectrum near the Northern limit of totality (p 8),

Mr J DE BOER, warrant officer of the Triangulation Brigade, with a *mandoer* (native foreman),

Mr J H OHLENROTH, mechanic of the railway workshops at Soerabaja

All the expenses of these officers, soldiers and gentlemen were defrayed by the Government

Finally, the promise was given that a man-of war would be stationed near the place of observation, so that the officers and crew might assist in the observations.

In January 1901 Dr FIGEE and Dr VAN BEMMELEN were authorized to take part in the expedition at the expense of the Observatory at Batavia, in order to make the necessary magnetical and meteorological observations during the eclipse

On March 22, 1901, Mr DE ROCHEMONT left Padang with his assistents, and with many cases and boxes, containing instruments, furniture, provisions, carpenter's tools etc At *Karang Sago* the building of the camp was begun at once, with the aid of many (up to 300) coolies, the site was to be cleared first, a *pagger* (fence) was made, and, in three weeks 15 huts, made of *bamboe*, *rottan* and *atap* were erected, viz barracks for the men, and the *jongens* (Malay servants), *goedangs* (barns) for the packing cases, a post office, a dark room, a mechanic's shop, containing a lathe, a carpenter's table and other appliances, *kammar mandi* (bathing-rooms) etc Norton wells were struck, procuring delicious water, oil lanterns and a flagstaff were erected Finally, a *hotel* (41 × 7 Meters) was built for the members of the expedition, consisting of 14 separate rooms, a general messroom, and a study, abundantly provided with everything necessary for drawing, writing, computing and so on (See Plate I)

On March 28 Mr MULLER arrived from Batavia at *Padang*, with many instruments and 80 cases of provisions, bought at cost-price, through the courtesy of the *Koninklyke Paketvaart Maatschappy* (Royal SS Company) On April 1 Mr MULLER visited the camp, he was accompanied by Mr DE BOER who was to make the necessary preparatives for the time and latitude observations A few days later Mr MULLER found Mr WACKERS at Padang, and on April 6 welcomed the Dutch and foreign astronomers at *Emmahaven*, who had arrived there the same day on board the SS *Koningin Regentes*

Three days were spent, at Padang, in official calls and in buying several little necessaries Finally, on April 10, Messrs MULLER, WACKERS, JULIUS, WILTERDINK, HUBRECHT and the writer travelled to the camp on board the *Condor*, with the greater part of the instrument boxes, the other half having been transported, the day before, by Mr OHLENROTH On board was also the English Government Expedition (Messrs DYSON and ATKINSON), who used this opportunity to visit the island *Aoer Gadang*, where they hoped to find a suitable site for an eclipse camp

The *Condor* made a trip through the beautiful bay of *Taroesan* and after a four hours' delightful voyage, reached the roads of *Karang Sago* A beacon had been erected at the point where we

were to go ashore Men and instruments were transported on little rafts made of native *sampans* (boats), the men were landed by means of a *tandoe* (sedan-chair), the instrument boxes up to the number of 60 were *pikolled* (carried on the shoulder) to the camp, a distance of 200 Meters It was a curious sight, thirty or forty coolies *pikolling* the big prismatic camera box, weighing no less than 350 K G, by means of a huge and extremely complicated framework of *bamboe*

In this very comfortable camp we lived *en villegiature* from April 10 to May 24, and a most pleasant abode it was, too, but for a serious accident, that occurred on May 3 (See p 16)

We got up at half past five, and worked till half past twelve when we met in the messroom to talk matters over, to have a drink and to prepare for the excellent *rysttafel* at one o'clock After the *rysttafel* the real Indian resident ought to take a *siesta* till 4 o clock to avoid the hottest hours of the day Most of us, however, had to take the best advantage of daylight for the campwork, and worked from two till sunset Then a second bath was taken, and a second drink, letters — a mail coming and going three times a week — were written and read, the illustrated papers and magazines of the *leestrommel* were looked over, — the *Eclipskamp Karang Sago* having joined a *Painan* reading club — matters were again talked over, plans were made till, at 8 o'clock, Mr DE ROCHEMONT said *Ardjo, soeroe angkat makanan*, dinner being ready

In May, of course, much night work was to be done for the adjustment of the instruments by means of observations of stars

Camp life was gladdened by the beautiful comet 1901 I (A N N° 3763), we saw for the first time on the 5th of May, having been informed by a telegram from an American camp, and by a few short visits to the picturesque *kampong Salido* at 1,5 K M distance, and to the friendly town of *Painan* (at 4 K M) where we were very hospitably entertained by Mr VAN LOGHEM, the *assistent resident* This official visited us several times and so did the English expedition, Messrs DYSON and ATKINSON, who occupied the station at *Aoer Gadang* On May 6 Mr NEWALL, who was stationed at *Sawah Loentoh* came, accompanied by his volunteer assistant Dr WALLACE On May 12 several Malay chiefs visited the camp, and showed a lively interest in the instruments On May 14 finally a large party of distinguished visitors, officials and non officials, astronomers pressmen, officers, ladies and gentlemen from Padang arrived on board the *Condor*, amongst whom I may mention Minister ABENDANON, *Chef van het Departement van Onderwys, Eeredienst en Nyverheid*,

Colonel VAN BIJLEVELT, *Gouverneur* JOEKES, and three Belgian astronomers from St Xavier's College, Calcutta Some gentlemen of this party kindly reciprocated the instrumental show we had given them by the performance of a "waterballet", the raft that brought them back to the steamer going to pieces *All is well that ends well*

The day after our arrival in the camp the preliminary work was begun the unpacking of the instruments (which appeared almost without exception to be in good condition), the surveying of the locality and the building of several (22) piers for the astronomical, physical, magnetical and meteorological instruments

The piers were made of brick masonry, on a foundation of heavy stones from the *kali* (river) The soil being very sandy, there was no danger of giving way Though the Indian bricks are very frail, the piers, even the rather high and slender one, carrying the heavy 10-inch coronagraph (see p 6) held out well and proved to be very solid, after all Perhaps it would be advantageous to take out ready made iron plates that may be joined together and filled with concrete

Referring to the special reports for full particulars about the construction and the dimensions of the piers, and about the adjustment of the instruments, I only wish to call attention, in this *General Account*, to the complex of instruments, indicated, on the accompanying plan (Plate I, see also Plate III) by the letters *c*—*j* As the sun's declination on the 18th of May is North, and consequently the Northern mirrors of the double polar siderostats worked at the more favorable angle of incidence, the instruments with large openings (the 6 inch prismatic camera, and the 4 inch STEINHEIL lens, to be used as an image lens for the visual spectroscope) were placed North The siderostats had FOUCAULT regulators and were constructed, after Mr WILTERDINK's indications, by P GAUTIER of Paris, so as to allow of a rotation of the mirrors in both directions, in order that North and South pole might be interchanged, if necessary The rotation could also be regulated, by a simple manipulation, at half rate, in case circumstances would make it preferable to use the mirrors as coelostats

As, on account of the moisture, the use of mirrors in tropical countries is, to some extent, a drawback, I shall give some information about Mr WILTERDINK's method of packing the five precious and sensitive glasses Each mirror was packed in a wooden box the bottom of which had been partly taken away so as to make the glass rest on the bottom with the edge only of the silvered surface

In order that no moisture or resin from the wood might damage the silver, the bottom was covered with tin foil The packing of the mirrors took place in a dry room, the boxes, after having been carefully closed, were wrapped up in tin foil and solded in five zinc boxes

Thanks to this careful packing the mirrors were in a perfect condition when the zinc boxes were opened in the camp When not in use they were kept in the zinc boxes and protected, as far as possible, against moisture by rough pieces of *Ca O* Thanks to these measures, they did not seem to suffer from the moisture laden tropical atmosphere Unfortunately, however, the mirrors could not satisfactorily be kept free from dust, though the soil under and near the siderostats was covered with wet sawdust

At *Karang Sago* the double polar siderostats were made to rotate in 24 hours and consequently worked as real siderostats, throwing two beams of light in the direction of the earth's axis Siderostat *e*, however, carried, parallel to the polar axis, a second axis which was made to rotate in 48 hours, by means of a steel strap A coelostat mirror, diameter 25 cm, was mounted on this axis, so as to throw a beam of sunlight nearly horizontally in a direction, whose azimuth was 289°, this direction having the sun's declination of May 18 with opposite sign The coelostat mirror fed the American 40 foot lens, the tube (see p 8) and the dark hut of which were constructed in the same way and with the same materials (*atap*, *bamboe* and *rottan*) as all the other buildings in the camp, both tube and hut were made light tight by means of a double layer of black cloth

On April 23 the last pillar was ready, the greater number of the instruments was already in position, protected by huts or sheds of *bamboe* and *atap* The long light-tight tube and hut for the 40 foot coronagraph were only ready on April 30

The accompanying plan of part of the camp (Plate I) gives an idea of the relative positions of the instruments See also Plate II, showing a view of part of the camp

The adjustment of the instruments occupied the members of the expedition up to the last day

A heavy blow struck us by the accident already alluded to (p 14), which happened to Mr WILTERDINK on May 3 while occupied with the writer with the adjustment of the 10 inch coronagraph, he fell from a wooden scaffolding and broke his right radius Not only was the use of his hand strictly forbidden him, but he had to be transported to Padang for a few days, and though after his return he constantly assisted the other members with his advice, he was

not able during the eclipse to take charge of one of the principal instruments

Unnecessary to say that, while Mr WILTERDINK and the writer led the adjustments of the astronomical instruments, Mr JULIUS did the same for the physical instruments

The erection of the magnetical and meteorological instruments was started on April 27, under the direction of Mr VAN BEMMELEN, who arrived in the camp the day before, and of Mr S FIGEE, who arrived on May 7, accompanied by his son Mr TH FIGEE, volunteer assistant

Meteorological observations were daily carried out from April 28 to May 19

On May 7 captain KERKHOFF visited the camp in order to study under the direction of Mr JULIUS and the writer, the objective grating spectrograph to be erected near the Northern limit of totality

The number of assistants was completed, on May 16, by the arrival of Mr NIEWENHUYS, the well known photographer from Padang

Captain WACKERS had been charged with the time, latitude and azimuth observations

A Time

The expedition disposed of four chronometers, DENT 40622, DE CASSERES 610 and 625, and HOHWU 628, DE CASSERES 625 always being used at the observations Time was determined by altitudes of stars near the prime vertical, by means of a 10 inch PISTOR and MARTINS Universal Instrument The stars' places were taken from the *Berliner Astr Jahrbuch* The daily rates were found to be

	D	*C* 610	*C* 625	*H*
April 12—14	—4 97	+4 31	+1^{s}94	+0^{s}13
14—21	—4 84	+4 48	+1 79	+0 29
21—30	—4 93	+4 3[illegible]	+2 22	+0 20
30—39	—4 78	+4 45	+2 14	+0 26
May 9—12	—4 91	+4 42	+1 58	+0 28
12—16	—5 05	+4 41	+1 83	+0 45
16—18	—4 90	+3 94	+1 80	—0 13

The chronometer HOHWU 628 has been used at the practice drills (see p 20) and at the day of the eclipse

B Latitude

The latitude of the pillar of the Universal Instrument was determined by circummeridian altitudes of stars, each determination consisted of

6 altitudes, viz 3 in each position of the instrument The results are:

April 14	γ *Scorpii*	(S)	$\varphi = 1° 19' 27''6$ S
16	γ *Herculis*	(N)	26 3
21	π *Bootis*	(N)	28 8
21	κ *Serpentis*	(N)	26 8
	Mean		$\varphi = 1° 19' 27''5$ S

C Azimuth

On the slope of the *Boekit Salido*, a little hill at a distance of 300 M, a nightsignal had been erected, the azimuth of which was determined by stars near the horizon and not far from the prime vertical

Results

April 30	α *Hydrae*	(W)	311° 47′ 27″1
30	α *Aquilae*	(E)	27 8
	Mean		311° 47′ 27″5

By means of this azimuth the polar axes of the instruments were set North-South, the final adjustments, of course, being made by direct observations

D Longitude

The longitude of the camp could not be accurately determined It was taken from a topographical map, scale 1 20 000 and found to be 0 11′ 24″ E of *Padang*, the East longitude of Padang being approximately 100° 21′ 55″, the longitude of the camp at *Karang Sago* is to be estimated at 100° 33′ 19″ E of Greenwich (see p 22)

The uncertainty of the longitude of the place of observation and the experiences from former eclipses pointed to the desirability of deriving the last warning sign of "ready" not from the computation, but from the observation of the eclipse itself It was arranged that Mr MULLER should give this sign, when in the dark hut of the 40 foot coronagraph the crescent of the sun measured 45 According to computation [1]) this would occur 16^s before the beginning of totality Moreover, a look out on the top of a *bamboe* tower, 8 M high, was to watch the search light of the English man of war *Pigmy*,

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[1]) An arc of $\alpha°$ is covered by the Sun's crescent at $x = \frac{t}{2}\left(sec\,\frac{\alpha}{2} - 1\right)$ seconds before second contact, t being the duration of totality in seconds For $t = 392^s$, the estimated duration at *Karang Sago* (see p 21),

$x = 16^s2$ for $\alpha = 45$

$x = 81^s$ for $\alpha = 90°$

stationed at *Aoer Gadang*, which light would, at our request, be screened off at the moment when totality began at that station. Computation had shown, that the shadow would reach our camp about 15^s later.

On May 7 *H. M. pantserdekkorvet Sumatra*, under temporary command of the *Luitenant ter zee* 1e *klasse* A. GELDERMAN arrived at the roads. Most of the instruments, as already mentioned, had been erected, at that date, but they still required the final adjustments.

Messrs. MULLER, WILTERDINK and the writer had in the meantime drawn up a programme for the astronomical observation while Mr. JULIUS did the same for the physical observations.

For full particulars the reader is referred to the special reports. Here I shall only call attention to the general distribution of work [1]):

Chronometers: 2 assistants,

Siderostats (e and f): 3 assistants,

Large spectrograph (h): Mr. S. FIGEE with 2 assistants,

Small spectrograph (g): Mr. DE ROCHEMONT with 6 assistants,

Spectroscope (i): Mr. HUBRECHT with 3 assistants,

Prismatic camera (j): Mr. NIJLAND with 4 assistants,

40 *foot coronagraph (c)*: Mr. MULLER with 3 assistants,

10 *inch coronagraph (b)*: Mr. WACKERS with 5 assistants,

Coronagraphs on polar axis (a): midshipman BRANDT with 10 assistants,

Photometer (q): Mr. VAN BEMMELEN and midshipman Baron MACKAY with 2 assistants,

Heat actinometer (m): Mr. JULIUS with 4 assistants,

Polarimeter (l): lieutenant v. d. ESCH with 3 assistants,

Pyrheliometer (o): 2 assistants,

Cloud-theodolite (x): lieutenant DE BRUYN[illegible]L with 1 assistant,

Observations of wind (t): 2 assistants,

Thermometers (r): 4 assistants,

Atmospheric electricity (u): Mr. TH. FIGEE,

Declinometer (s): 2 assistants,

Drawings of corona: midshipman B[illegible] with 4 assistants,

Shadowbands and further observations (color of corona and landscape, visibility of stars): midshipmen LANGELAAN and BUDDING with 14 assistants,

Look out: one assistant.

The total number of observers was thus 93, of whom 7 were officers and 68 non commissioned officers and men of the *Sumatra*.

It will be seen, that, on account of his broken radius, Mr. WILTERDINK

[1]) The letters in brackets refer to the plates.

did not participate in the effective work. It is unnecessary to say, that this was very bad luck. Having been transported to Padang on May 11, he did not return untill the 16th.

Under direction of Messrs MULLER, JULIUS and the writer thirty practice drills were held from May 12 tot 17, some of them in the evening in order to be used to lamplight for the reading of chronometer faces, scales etc., in case the eclipse should prove to be a very dark one. The meteorological observers and assistants did not take part in these drills, their work not being confined to the stirring and exciting six minutes of totality. The observers of shadow bands and further phenomena, and the corona sketchers practiced apart. A corona drawing, varied from day to day, was hung up at the height (70°) of the eclipsed sun, and was drawn by 8 men, each being only responsible for one quadrant; as Mr BATSEM undertook to draw the whole of it, the result should be 3 complete sketches. Shadowbands shall be observed on a horizontal and on two vertical screens, orientated East West and North South. At the rehearsals a frame work of *bamboe* was carried quickly along, giving moving shadows that had to be observed as accurately as possible.

For full details I again refer to the special reports. Here I shall only mention the general mode of proceeding.

5^m before totality: every man at his post and ready.

81^s before totality: The word „*klaar*" (ready) given by Mr WACKERS, who states, on the ground glass of the 10-inch coronagraph, that the sun's crescent covers an arc of 90°.

40^s later: Time keeper *A* calls out „*spiegels*" (mirrors), the three assistants take the caps off the mirrors, their task being further to pay attention to the siderostats in order that no unexpected impediment might occur.

15^s or 16^s before totality: Call „*opgepast*" (attention) either by Mr MULLER, when the sun's crescent is seen to cover an arc of 45°, or by the look out, when the search-light of the *Pigmy* is screened off. The call „*opgepast*" is to be repeated, in either case, by time-keeper *A*.

Beginning of totality, as observed by Mr MULLER in the dark hut of the 40 foot lens. Call „*los*" (go). Time-keeper *B* begins the counting of seconds *nul*, *één*, *twee* ... *A* tries to estimate the interval between „*los*" and „*nul*" and notes the chronometer reading corresponding to the count *ten*. Time keeper *B* goes on counting up to 200 and is then relieved by *A*; thus the 200th second is counted by both *A* and *B*. In case no sun is visible at the beginning of totality, „*nul*" is called out at $12^h\,19^m\,51^s$ local civil time.

380^s after the beginning of totality, or, in case the 2^{nd} contact is lost, at $12^h\ 26^m\ 11^s$ call „*sluiten*" (shut) by time keeper *B*.

End of totality. Call „*over*" by Mr. MULLER, time keeper *A* goes on counting till Mr. MULLER emerges from the dark hut and notes the chronometer reading.

In the beginning of May the English astronomer NEWALL, who was stationed at *Sawah Loentoh*, sent notice that he had been informed by the *Nautical Almanac Office* at London that the duration of totality at *Karang Sago* would be $6^m\ 22^s$ instead of $6^m\ 32^s$. It was decided, in order to be on the safe side, that all cameras should be shut on the 380^{th} second after the beginning of totality.

In the evening of May 17 the drills had to be stopped owing to the rain. In the night the 41 plateholders were filled (viz. 6 for the prismatic camera, 9 for the 10 inch coronagraph, 24 for the four coronagraphs on the polar axis and 2 for the spectrographs), and the large plates (50 by 60 cm.) of the 40 foot lens were placed on the frame in the dark hut.

On May 18, at day break the sky was wholly overcast. Bye and bye the clouds grew thinner and at 11 o'clock the weather was nearly perfect. Then altocumuli began to gather and the eclipse has unfortunately been observed through a rather thick veil of clouds.

At 9^h the mirrors were placed in their cells and cleaned as far as possible from dust by means of very light flocks of wool cotton. Windscreens, tables for the corona sketchers and screens for the observation of shadowbands were placed.

10^h. Lamps were prepared.

$10^h\ 45^m$. First appearance of the moon on the sun's disc observed. Much ado with smoke glasses. Increasing interest of sailors and soldiers.

11^h. Sheds taken away.

$11^h\ 20^m$. Clockwork of polar axis started.

$11^h\ 30^m$. Clockwork of siderostats started, slits of spectrographs controlled.

$12^h\ 0^m$. Plate-holders taken from the dark room, wrapped up in black velvet, clockworks of the BURCKHALTER diaphragms wound up, lamps lighted,

$12^h\ 10^m$. Assistants formed into line,

$12^h\ 15^m$. Every man ready.

The programme began and was for the greater part promptly carried out.

Unfortunately, the nervousness of one of the assistants has made the results of the *small spectrograph* entirely useless.

The sign „*klaar*" was given at $12^h\ 18^m\ 51^s$, the word „*spiegels*" at $12^h\ 19^m\ 31^s$. When the caps had been removed from the mirrors, the image of the sun's thin crescent fell on a cardboard in the dark hut of the 40 foot lens. It was not quite sharp — the visual focus falling behind the chemical — and moreover undulated very much. Owing to these facts and to the clouds, Mr MULLER could not give the warning sign „*opgepast*". The look out gave it at $12^h\ 19^m\ 46^s$. Even the second contact was not accurately observed in the dark 40-foot hut. The sign „*los*" was given at $12^h\ 19^m\ 57^s.4$, presumably 2^s late. Thus the 2nd contact is to be put at $12^h\ 19^m\ 55^s$. This is only 9^s later than the look outs „*opgepast*". According to Mr DYSON (Proceedings Royal Soc. 69 p. 241) second contact at *Aoer Gadang* was observed at $12^h\ 19^m\ 30^s$ local time, i. e. at $12^h\ 19^m\ 46^s$ *Karang Sago* time, the East longitude of *Poelau Aoer Gadang* being approximately 100° 29′ 13″ (see p. 18).

Before the call „*sluiten*" (count 380) sunlight reappeared. The sign „*over*" was only given at count 381, probably 3 seconds late. Third contact is to be put at $12^h\ 26^m\ 16^s$, the duration of totality, therefore was $6^m\ 21^s$, agreeing closely with the value kindly forwarded by Mr NEWALL (see p. 21) and based on DOWNING's value for the semidiameter of the Moon, derived from a recent discussion of eclipse observations. At *Aoer Gadang* the duration of totality was also observed to be $6^m\ 21^s$ (see Mr DYSON's report, Proc. R. S. 69 p. 241). This means that at *Aoer Gadang* the times of both second and third contacts were recorded only 9^s earlier than at *Karang Sago*, though computation had given 15^s (see p. 19). As the English astronomers made no special time observations, their intention being only to observe the *duration* of the eclipse, the controversy is very likely to be ascribed to an error in the times given by Mr DYSON's report (the duration being correct), or may partly be caused by an error in the assumed difference of longitude ($16^s.4$) between *Aoer Gadang* and *Karang Sago*. Both errors may also allow for the curious fact, that our look out's „*opgepast*" was recorded at *the same instant* which the English Preliminary Report gives as the time of second contact ($12^h\ 19^m\ 30^s$ *A. G.* time $= 12^h\ 19^m\ 46^s$ *K. S.* time).

The East longitude (see p. 18) of *Karang Sago* was found to be

from the observed 2nd contact $6^h\ 42^m\ 9^s.8$

„ „ „ 3rd „ 10.0

mean $6^h\ 42^m\ 9^s.9 = 100°\ 32'\ 29''$

In this computation DOWNING's „eclipse" value (15′ 31″.47) of the Moon's mean semidiameter was used and corrections + 0s.14, — 1″.6 (kindly forwarded by Mr. DYSON) were applied to the Moon's right ascension and declination.

During totality the blue of the sky was very pale and greyish, the scenery was illuminated by the well known dull, gloomy, ghastly eclipse light. The clouds at 50° West of the eclipsed sun looked fallow or had a dingy orange tint. And round the inky black moon the double *fishtail* of the brilliant silvery corona was visible through the gaps in the cirrhusclouds: a most glorious sight, never to be forgotten. The Southern border of the Eastern *fishtail* pointed to two brilliant stars: *Venus* and *Mercury*.

No noise was heard, the Malay population having been warned by Mr. VAN LOGHEM, *assistant resident van Paman* to keep quiet and not to hinder the observations by screaming, as they were likely to do. *Kalongs* (great bats) are said to have left their hiding places, as if it were night. The curious „*chromatic bird*" we heard every evening in the camp, sang out of tune! On the native population of the camp the eclipse evidently did not make a very strong impression: when I asked my Malay servant what he thought of the *grahana matahari* he simply answered: „*gelap*" (dark).

With a HILGER „film prism", adjusted on one of the tubes of an excellent VOIGTLANDER binocular (aperture 45 mm., power 3,3) I tried, as far as circumstances permitted, to catch a glimpse of FRAUNHOFER lines. As much as seven minutes before totality the first lines appeared, in spite of the clouds. *D*, *E*, *b*, *F* and *G* could be readily seen. During totality (count 120 to 240) I could make out the North-East quadrant of a faint coronal ring. In this phase of the eclipse no *C*, D_3 or *F* rings were to be seen, but circumstances were not very favorable. Later, (count 320 to 340) however, I saw the *C*, D_3 and *F* rings very distinctly but now no green coronal ring was seen. At count 378 the photosphere burst out brilliantly. I had then to expose the last prismatic camera plate for the second flash-spectrum. After this I again looked through the HILGER prism at $12^h\ 28^m\ 3^s$ (i.e. 107 seconds after third contact), the sun being momentarily free from clouds, a number of FRAUNHOFER lines was visible, all of them, however, much fainter than the few I saw at $12^h\ 12^m\ 53^s$.

Shadowbands have not been observed; besides *Venus* and *Mercury* only *Aldebaran* and a few stars in *Perseus* were visible. As a con-

sequence of the rather heavy clouds it was not nearly so dark during the eclipse as had been expected, so that the lamps which were kept ready have not been used, the general illumination was stronger than at full moon

Immediately after the eclipse it was known that the *spectroscope*, the *photometer* and the *small spectrograph* had given no results

It was to be feared, of course, that the clouds would also have spoiled the greater part of the other observations and photograph

In the afternoon of May 18, some instruments were already dismounted, after having been photographed by Mr NIEUWENHUIS, and packed again in their boxes At 5 o'clock all the observers, astronomers, officers, marines and sailors were grouped on and round the look-out's *bamboe* tower, a picture was made (Plate IV) and Mr MULLER took advantage of the opportunity of expressing our cordial thanks for the most valuable assistance rendered by the officers and crew of the *Sumatra* On the following days many other pictures of instruments and groups were made, the dismounting and packing went steadily on, great assistance being given by the crew of the *Sumatra*, on May 22, 25 boxes could already be shipped to Padang

Immediately after the eclipse, the photographer Mr NIEUWENHUIS set to work to develop the plates, using many kilograms of ice The last plate was developed on May 22, it appeared, that also the exposure with the *large spectrograph* was an entire failure

I shall leave further details concerning the results obtained for the special reports See also the „*Preliminary Report*"

On May 22 Mr KERKHOFF arrived at the camp with the plate exposed by him at the Northern limit of totality unfortunately this plate too brought a disappointment Apparently the instrument had been adjusted correctly, but by a misunderstanding, and in consequence of the fact that the Northern limit was actually further North than had been expected according to the computation, the moment of observation was not well chosen the observer failed to get the phenomenon of the flash and photographed the spectrum of the corona instead, for which the lens however was not rapid enough

After this the members of the expedition successively left the camp Messrs S and TH FIGEE had already departed on May 19 by the steamship *Condor*, on the 22[nd] the *Condor* brought Messrs WACKERS and KERKHOFF and 25 boxes to Padang Finally, on the morning of the 24[th], everything being packed and ready Messrs

MULLER JULIUS, WILTERDINK, VAN BEMMELEN, HUBRECHT and the writer embarked (Plate V) on board the *Sumatra*, bound for Padang, whereas, in the afternoon, Messrs DE ROCHEMONT, DE BOER, NIEUWENHUYS and OHLENROTH left the camp by the SS *Condor* with the remaining assistants and cases At *Emmahaven* we cordially bade farewell to the commander (*kapitein-luitenant ter zee* C A DE BRAUW) and the officers of the *Sumatra*

Mr MULLER undertook to have diapositives made and to send them to Holland together with the cases Thanks to his care every thing has arrived in good order

Not to mention in details many other kinds of administrative work (paying of bills, returning the borrowed furniture and tools to the owners etc), he prepared for the *vendutie* (auction) of the camp — every Indian resident sells his furniture when he removes — which took place on May 28, bringing in *f* 227 gross

In the mean time Messrs JULIUS, WILTERDINK, VAN BEMMELEN and the writer made a short trip to the rightly famous *Padangsche bovenlanden*, where they visited *Fort de Kock*, the *passer* of *Paya-kombo*, the cañon of *Harau*, the *Karbouwengat*, the lake *Singkara* etc , and where they were very pleased to meet some fellow astronomers, *i a* Prof BARNARD, Mrs and Mr NEWALL and Mr CURTISS

Messrs JULIUS, WILTERDINK and the writer left Padang on board the SS *Willem II* on May 29 and arrived at Batavia two days later, Messrs MULLER and VAN BEMMELEN who, being on an official trip, had to take the steamer *Imhoff*, left Padang on the same day but did not arrive at Batavia until June 1

At *Batavia* Messrs MULLER, JULIUS, WILTERDINK and the writer called on some high officials (Minister ABENDANON, Vice admiral STOKHUYZEN, Commander of the Navy and Lt General DE BRUYNE, Commander in chief of the Army) to express their thanks for the good care and many facilities which had been given to the expedition, on June 6 they had an audience with His Excellency the *Gouverneur Generaal* at *Buitenzorg*, and were invited to dinner in the evening

After this we scattered over *Java* to enjoy its beautiful scenery and its most interesting Hindu antiquities Everywhere we found fellow astronomers enjoying the same pleasures at the railway hotel in *Maos*, in *Djokjakarta*, at the famous Hindu temple *Boroboedoer*, and even in Java's Eastern districts, at *Tosari*

On June 26 Mr JULIUS returned to Holland, at *Padang* he took charge of the negatives Mr WILTERDINK and the writer left Batavia on June 29 to return home via Japan and America Before they left they had an opportunity to inspect, at the Batavia Observatory,

many drawings and descriptions which had been sent in by amateur observers, who had followed up the summoning contained in the above mentioned, „*Handleiding*" (see p 8)

After their return two more meetings (1901 Sept 27 and Dec 28) of the E C were held, chiefly to discuss the publication of the results It was decided, that the *physical observations* shall be treated by Mr JULIUS, the *photographs of the corona* shall be discussed, and the construction of the *slit-spectrographs* described by Mr WILTERDINK, the writer shall report on the *Prismatic Camera* and the results it yielded, and on the *Amateur observations* The Report shall be written in English, especially on behalf of the numerous American eclipse observers, though French was preferred, on the whole, by most members of the E C

A *Preliminary Report* has already been issued and distributed

At the end of this *Account* I wish to express, *in the name of the Eclipse Committee*, our most sincere thanks to such officials, gentlemen and scientific societies as have contributed to the success of the expedition For, though the scientific results are not what they should have been, and what they would have been probably, if the weather had favoured the observation, it is most encouraging to think of this very satisfactory and important result thanks to the cooperation of private and official initiatives a scientific enterprise of some extent has been possible

We are especially indebted to the private persons and the scientific societies, that contributed so liberally to the Eclipse Fund, to the civil and military authorities of the Netherlands and the Indian Governments, who, as has already been pointed out, did everything possible to promote the interests of the expedition

H E the *Minister van Binnenlandsche Zaken* (home affairs, interior), H E the *Minister van Kolonien*, H E the *Gouverneur-Generaal van Nederlandsch Indie*, *Lt Generaal* W ROOSEBOOM,

Minister J H ABENDANON, *Directeur van Onderwijs, Eeredienst en Nijverheid*, Mr A M JOEKES, *Gouverneur van Sumatra's Westkust*, Mr TH F A DELPRAT, *Chef van den dienst der Staatsspoorwegen* (Director of the railways) *ter Sumatra's Westkust*, Mr D K A VAN LOGHEM, *assistent-resident van Painan*, who rendered most valuable assistance in the building of the camp and in the preparatives of the

observation, Mr J BERMAN, *Hoofdinspecteur, chef van den Post en Telegraafdienst*,

H E the *Vice-admiraal* F J STOKHUYZEN, Commander of the Navy,

H E the *Lt-Generaal* H C P DE BRUYN, Commander of the Army, *Kolonel* H F C VAN BIJLEVELT, at Padang, *Kolonel* A J J STAAL, *Chef der Genie*, and *Majoor* J W C VAN SIELDEN, *eerstaanwezend Genie officier te Padang* (both belonging to the corps of Military Engineers), *Kolonel* J H DE SAUVAGE, *Hoofd-intendant*, and *Majoor* J E VAN SCHAIK, *Gewestelyk intendant te Padang* (both of the Military administration),

to the *Maatschappy* (SS Company) „*Nederland*" for the liberal arrangements in the conveyance of the observers and their instruments, to the *Koninklyke Paketvaart Maatschappy* for procuring us provisions at cost price, to Messrs FIGEE, VAN BEMMELEN, WACKERS, DE ROCHEMONT, KERKHOFF and HUBRECHT for the essential part they took in the observation,

to the officers and the crew of the *Sumatra* for the most valuable and substantial assistance they rendered to the professional astronomers,

finally to the *Koninklyke Natuurkundige Vereeniging* (Physical Society) at Batavia for the way it prepared the expedition, and, last but not least, to this Society's President, *Majoor* J J A MULLER, Sc D, the able and clever leader of the Expedition

A A NIJLAND, Sc D

Utrecht, March 1903 *Professor of Astronomy*

TOTAL ECLIPSE OF THE SUN,

May 18, 1901

Reports on the Dutch Expedition

TO

KARANG SAGO SUMATRA

Published by the Eclipse Committee of the Royal Academy,
Amsterdam

No 2 MAGNETIC OBSERVATIONS

BY

Dr. W VAN BEMMELEN.

TOTAL SOLAR ECLIPSE
May 18, 1901

Magnetic Observations at Batavia and Karang Sago (Sumatra)

BY

W VAN BEMMELEN

During the Solar eclipse of May 28 1900 Dr L A BAUER organised observations in the United States of *North America* as to the declination and horizontal intensity which, in connection with the registration of the vertical intensity at *Toronto* led to the probable result that the eclipse caused in the atmosphere a phenomenon to be compared to a magnetic pole following the central shade on its way through our atmosphere and attracting the north end of the needle [1])

The insufficient number of stations of observation the scantiness of the presumed influence in comparison with the ever to be expected irregular oscillations in the terrestrial magnetic force were, in consideration of the importance of a possible existence of that influence, sufficient occasion for BAUER to make a general appeal for a closer observation on May 18 1901

On behalf of the Batavia Observatory observations were made in the eclipse camp at *Karang Sago (Sumatra)*, while at *Batavia* observations were made possible by the Batavia Electric Car Company stopping its traffic in compliance with a request made by the Direction of the Observatory

At *Karang Sago* photographic self registering instruments for declination and horizontal intensity were mounted, likewise a declino

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[1]) Cf Terrestrial Magnetism V 4

variometer for visual observation A variometer for the vertical intensity which would have required a very sensitive magnetic balance was not available

The photographic instruments with the registering apparatus were mounted on a large pillar in a bamboo hut with thick dense walls the intensity instrument having moreover been protected from quick and great variations of temperature by cottonwool and cloths

The visual declinometer was set up in another hut, and allowed the declination to be read with accuracy to two seconds of arc a few hours before eclipse time however the thread gave way and the stretching of a new one entirely spoiled the observation

For the Hor Int an old MEYERSTEIN unifilar with a thick brass box was made use of in which a cylindrical magnet was suspended by new silver wire (length 43 cm) and brought in a perpendicular direction at the magnetic meridian by torsion only

A thermometer was placed in the magnetbox

The declinometer was an old LAMONT variation apparatus with a magnet consisting of three lamellae (78 $\times$ 6 mm) attached to a cocoon thread 45 centimeters long

The benzine lamps for both the instruments were also placed on the broad pillar surface the ray of light returning from the declination instrument being reflected by a mirror in the direction of the registering cylinder

The photographic paper was wound on a RICHARD pattern revolvingcylinder

Two cylinders — one with a revolving time of six hours the other of twenty four — were employed by turns being introduced into a wooden case in the front wall of which was a cylinder lense

A mirror separately set up threw a base line on the paper

The testing at *Batavia* compared with the records of ADIE s magnetograph supplied the following result for the scale value of the Hor Int instrument

1 mm = 0 89 γ (Jan 22—23, 1901)

For influence of temperature, I found

Extreme temp 27 °30 and 31 °62 4 6 mm per 1° C
March 9—10

Extreme temp 26 85 and 32 56 6 6 mm per 1° C
March 12—13

As a double weight is to be given to the last determination we find

$$5.9 \text{ mm per } 1^\circ \mathrm{C}$$

At *Karang Sago* the scale value was determined by alternately placing a deflector magnet at equal distances from the H and D magnets perpendicularly on each of the two magnets

Result

$$1 \text{ mm} = 1.0\,\gamma \qquad \text{May 6}$$

The influence of temperature was determined by heating the hut with numerous lamps the variation of the H F being determined by comparison with the Batavia magnetogram

Result

$$5.0 \text{ mm per } 1^\circ \mathrm{C} \qquad \text{May 19—20}$$

The distance from cylinder to mirror gave the following scale value for the declinogram

$$1 \text{ mm} = 1'.10$$

The thermometer of the H instrument was read at irregular hours, the readings however gave sufficient information about the daily variation of temperature

Date	Loc time Reading	Loc time Reading	Loc time Reading	Loc time Reading	Loc time Reading
May 9	7h 25m 27 34		12h 0m 27 92		7h 57m 28 92
10	6 25 42		11 45 27 76	4h 50m 28 22	8 14 28 30
11	6 15 07	9h 10m 27 26	11 10 27 71		8 50 28 46
13	6 27 40 7 40 68			3 45 29 22	6 27 29 00
14	6 29 24		12 30 27 76	3 0 28 16	6 41 28 50
15	7 1 10		12 10 28 36		8 38 28 80
16	6 42 74			5 15 28 40	7 13 28 36
17	6 58 02	10 0 28 00		3 30 27 45	7 0 27 40
Mean	6 48 27 31	9 51 27 10	11 55 27 90	4 6 28 27	7 38 28 47

Accordingly the increase of temperature is only about one seventh of that to the open air and the maximum was not reached until late in the evening which proves the adequacy of the measures taken in order to protect the magnet against rapid and great variations of temperature

For establishing the normal daily oscillation of H and D at *Karang Sago*, the records for the period May 9—17 were available

After elimination of one day with disturbance (May 10) and one with failed registration (May 12) the reading of the magneto grams gives the following hourly values uncorrected only the mean values having been corrected

Hourly values (relative) of the Horizontal Intensity and Declination at *Karang Sago* uncorrected for temperature

Unity $\gamma = 0.00001$ C G S

Horizontal Intensity

Local time	8h	9h	10h	11h	Noon	1h	2h	3h	4h	5h	6h
May 9	—19.4	10.4	19.5	22.1	22.1	17.1	7.7	0.6	—13.4	—27.9	—39.1
11	—53.1	— 8.7	13.9	15.2	18.9	15.4	17.0	8.4	— 2.2	— 9.3	—15.7
13	—27.9	— 4.5	5.1	13.9	15.1	12.3	9.6	5.0	— 3.7	—11.4	—13.9
14	—29.6	— 1.2	1.4	4.9	11.6	14.4	11.9	6.4	— 3.5	— 4.6	—11.6
15	—35.1	0.1	10.2	24.5	25.7	17.7	9.1	— 7.2	—10.2	—14.4	—20.7
16	—34.4	— 7.0	18.4	25.4	21.6	16.1	15.3	4.6	—14.4	—21.3	—24.1
17	-18.8	4.9	20.7	27.2	31.2	22.1	6.1	—10.2	—19.1	—27.5	—36.1
Mean	—31.2	— 0.9	12.7	19.0	20.9	16.4	11.0	1.1	— 9.5	—16.6	—23.0
Temp corr	3.0	2.8	2.6	1.1	0.1	— 0.6	— 1.0	— 1.4	— 1.7	— 2.1	— 2.4
Corr mean	—28.2	1.9	15.3	20.1	21.0	15.8	10.0	— 0.3	—11.2	—18.7	—25.4

Declination

Local time	8h	9h	10h	11h	Noon	1h	2h	3h	4h	5h	6h
May 9	0.4	—0.6	—0.2	—0.4	—0.6	—0.1	0.0	0.1	0.4	0.4	0.4
11	1.0	— 0.7	— 1.3	— 0.7	— 0.6	— 0.8	— 0.6	0.2	0.4	1.0	1.4
12	0.9	0.1	0.1	— 0.7	— 0.9	— 1.0	— 0.4	0.3	0.4	0.7	0.9
13	1.2	0.1	— 0.6	— 1.5	— 1.8	— 1.4	— 0.8	0.1	1.1	1.7	1.8
14	1.2	— 0.[illegible]	— 0.6	— 1.1	— 1.5	— 0.4	— 0.1	0.6	1.0	1.0	1.1
15	1.0	— 0.2	— 0.3	— 1.3	— 1.5	— 1.0	— 0.3	0.6	1.0	1.0	0.8
16	— 0.1	— 1.2	— 1.0	— 0.3	— 0.2	0.1	0.0	0.3	1.1	0.8	0.6
17	0.3	— 0.4	— 0.4	0.0	— 0.1	0.1	0.8	0.0	— 0.4	0.0	0.3
Mean	0.75	—0.44	—0.54	—0.76	—0.89	—0.56	—0.18	0.28	0.64	0.81	0.94

The large amplitude of the diurnal variation of the *H F* is very remarkable it amounts to almost twice that observed at *Batavia* I see no reason to ascribe this difference to instrumental causes so that I cannot but admit the real existence of this phenomenon

During the period May 9—17 the 24 hour cylinder was registering by day and the 6 hour cylinder by night besides on May the 18th the 6 hour cylinder was used during eclipse time The correction to be applied in order to reduce the one set to the other was to be obtained by means of simultaneous observations made at the declinometer but since the latter observations failed it was impossible to ascertain the proper correction

The thermometer at the H instrument was only read before and after eclipse time on May the 18^{th} this trifling uncertainty about the variation of temperature was however amply made up for by the advantage of the magnetograph remaining wholly undisturbed

The temperatures read are

May 18	6^h	5^m	a m	26 °29
	7	26		26 18
	10	49		26 70
	2	35	p m	27 20
	4	39		27 54
	8	0		27 54

With these values a very acceptable curve of the probable temperature can be constructed from which curve the temperatures given in the table have been taken

In an astronomical camp the time was of course known with more than sufficient accuracy moreover a time signal was given on May the 18^{th} both at the beginning and the end of the registration on the 6 hour cylinder and also at 2 33 p m With respect to the Hor Int the magnetogram shows a clear and well defined curve permitting an easy reading to tenths of millimeters The curve for the Declination was somewhat less distinct but considering its great smoothness, the tenths of millimeters could by careful reading be estimated with sufficient accuracy

In the following table the variations dH and HdD are given in absolute units H being taken to be $= 0\ 367$ The zero point has been chosen arbitrarily

Values (relative) of the Components of the Horizontal Force observed at *Karang Sago*

May 18, 1901

Unity $\gamma = 0\ 00001$ C G S

Greenwich Time	Temperature H magnet	*dH*	*HdD*	Greenwich Time	Temperature H magnet	*dH*	*HdD*
$4^h\ 15^m$	26 °74	39 1	13 5	$5^h\ 28^m$	26 °95	24 4	11 2
18	75	38 2	14 2	29	95	24 3	11 2
21	76	37 6	14 7	30	95	23 8	11 2
24	77	37 3	14 7	31	96	23 4	11 2
27	78	35 5	14 7	32	96	23 2	11 2
30	80	35 0	14 7	33	96	23 1	11 2
33	81	34 9	14 7	34	96	23 0	10 7
36	82	34 7	14 7	35	96	22 8	10 7
39	83	34 3	14 7	36	96	22 7	9 5
42	84	33 6	14 2	37	97	22 6	9 5
45	85	33 1	13 5	38	97	22 3	9 5
48	86	32 2	13 5	39	97	22 1	9 5
51	87	31 5	13 5	40	97	21 7	9 5
54	88	31 3	13 0	41	97	21 6	9 5
57	89	31 3	12 4	42	98	21 3	8 8
5 0	90	30 1	11 9	43	98	21 1	8 8
3	91	30 5	11 2	44	98	21 2	8 8
6	92	30 6	11 2	45	98	21 2	8 8
9	93	30 0	11 2	46	98	21 4	8 8
12	93	29 1	11 2	47	98	21 5	8 8
15	93	28 2	11 2	48	98	21 7	9 5
18	93	27 1	10 7	49	98	21 8	9 5
19	93	26 8	10 7	50	98	21 8	9 9
20	93	26 7	10 7	51	99	21 8	9 9
21	94	26 5	10 7	52	99	21 9	11 2
22	94	26 4	10 7	53	99	22 0	11 2
23	94	26 1	10 7	54	99	22 1	12 1
24	94	25 8	10 7	55	99	22 0	12 1
25	94	25 5	10 7	56	99	22 0	12 1
26	95	25 2	10 7	57	27 00	22 0	12 1
27	95	25 0	10 7	58	00	22 0	13 0

Greenwich Time	Temperature H magnet	dH	HdD	Greenwich Time	Temperature H magnet	dH	HdD
5h 59m	27 °00	22 0	13 0	7h 15m	27 °11	21 4	20 1
6 0	00	22 0	13 5	18	12	21 8	20 6
1	00	21 8	13 5	21	12	21 8	20 1
2	00	21 6	13 7	24	13	22 2	19 4
3	00	21 4	13 7	27	14	22 3	18 3
4	00	21 1	13 7	30	14	22 5	18 3
5	00	21 0	13 7	33	15	22 3	16 5
6	00	20 9	15 4	36	16	22 2	17 1
7	00	20 8	15 4	39	16	21 9	16 5
8	01	20 7	15 4	42	17	21 2	17 1
9	01	20 5	15 4	45	18	20 9	16 5
10	01	20 3	15 9	48	19	20 7	15 9
11	01	20 1	15 9	51	20	20 5	15 9
12	01	19 9	15 9	54	20	20 5	13 5
13	01	19 9	15 9	57	21	20 4	13 5
14	01	19 9	15 9	8 0	21	20 1	13 5
15	01	19 9	17 1	3	22	19 6	13 5
16	02	19 8	17 1	6	23	19 4	15 9
17	02	19 8	17 1	9	24	18 8	15 9
18	02	19 8	17 1	12	25	18 7	17 1
21	03	19 8	18 3	15	26	18 2	17 1
24	03	19 5	18 3	18	27	17 8	17 1
27	04	19 6	18 3	21	27	17 3	17 7
30	04	19 9	18 9	24	28	17 1	17 7
33	04	20 1	20 1	27	28	16 6	18 3
36	05	20 0	20 1	30	29	15 9	18 3
39	05	20 1	20 1	33	29	15 4	18 3
42	05	20 2	21 3	36	30	14 6	19 4
45	06	20 5	21 3	39	30	13 8	17 1
48	06	21 1	21 8	42	31	13 4	17 1
51	07	21 4	21 8	45	32	12 9	17 1
54	07	21 6	22 4	48	33	12 4	17 1
57	08	21 9	22 4	51	34	11 9	15 9
7 0	08	22 0	21 8	54	35	11 3	14 7
3	08	21 4	21 8	57	36	11 0	13 5
6	09	21 2	20 6	0	37	10 4	12 4
9	10	21 2	20 6	3	38	10 1	12 4
12	11	21 2	20 6	6	39	9 7	13 5

Greenwich Time	Temperature *H* magnet	dH	HdH	Greenwich Time	Temperature *H* magnet	dH	HdD
$8^h\ 9^m$	27 °40	9 2	13 5	$8^h\ 30^m$	27 °47	6 8	10 0
12	41	8 8	12 4	33	48	5 6	10 0
15	42	8 6	12 0	36	49	4 0	10 0
18	43	8 3	10 0	39	50	3 3	10 0
21	44	7 8	10 0	42	52	2 4	11 2
24	45	7 7	10 0	45	53	1 1	11 2
27	46	7 3	10 0	48	54	0 1	11 2

Batavia

The Electric Car Company at *Batavia* stopped traffic from 11 30 a m to 2 30 p m, during which time two welltrained Javanese assistants read the WILD pattern Variation apparatus In regular succession each of the three instruments was read every thirty seconds Owing to a misunderstanding however the thermometers were not read

ADIE s magnetograph registered undisturbedly, the new and very sensitive thermographs with which both bifilar and balance were recently supplied, gave full information about the the variation of the temperature for which reason the eye readings of WILD s instruments have been reduced to the readings of the magnetograms The registration of the magnetograph before and after eclipse time although more or less disturbed by electric currents allows approximative readings being made

The normal variation for the Hor Int and Decl was obtained from the readings of the magnetograms in the same manner as at *Karang Sago*

From the readings of the WILD s instruments the values of H and D on the full minutes Greenwich time were graphically interpolated from the readings of WILD s instruments

WILD s balance having no sufficient sensitiveness, only the registration of the magnetograph balance was avaible

The scale values were

WILD s Variation apparatus	ADIE's Magnetograph
H 1 pars $= 2\ 77\ \gamma$	H 1 mm $= 5\ 3\ \gamma$
D , $= 0'\ 370$	D , $= 1'\ 14$
	V $= 1\ 95\ \gamma$

In the tables following H has been taken to be 0 367

The magnetograms of May 1901 cannot be used for the normal movement of the vertical intensity, owing to the great disturbances produced by electric currents, in stead of May of this sunpot minimum 1900—1901, May of the preceding minimum viz May 1887 was chosen

Mean (relative) hourly values of the magnetic components at *Batavia*

Unity $\gamma = 0\ 00001$ C G S

Batavia time		8h	9h	10h	11h	Noon	1h	2h	3h	4h	5h	6h
May 9—17, 1901	*dH*	28 6	31 8	39 8	43 5	38 2	20 2	21 7	12 7	4 3	0 5	0 0
" " "	*HdD*	13 5	23 1	27 7	27 6	22 1	15 8	8 9	4 4	0 0	3 2	7 8
May 1887	*dV*	7 3	4 8	1 5	0 0	1 5	1 5	3 6	6 7	12 5	19 5	22 8

Values (relative) of the magnetic components observed at *Batavia*

May 18, 1901

Unity $\gamma = 0\ 00001$ C G S

Greenwich Time	*dH*	*HdD*	*dV*	Greenwich Time	*dH*	*HdD*	*dV*
$1^h\ 0^m$	10 8	17 6	14 1	$4^h\ 31^m$	28 0	27 5	
30	16 8	21 3	13 8	32	27 6	27 3	
2 0	21 1	23 7	12 8	33	27 4	27 3	
30	26 9	26 1	9 2	34	27 7	26 9	
3 0	30 1	29 8	6 5	35	27 9	26 2	
30	31 7	28 6	5 2	36	27 9	25 5	
4 0	30 0	31 1	6 0	37	27 3	24 9	
23	29 7	28 9		38	26 8	24 9	
24	29 3	28 9		39	26 7	24 9	
25	28 8	28 9		40	26 7	24 9	8 0
26	28 2	28 9		41	26 6	24 9	
27	27 8	28 9		42	25 9	24 9	
28	27 6	28 7		43	25 4	24 7	
29	28 0	28 5		44	25 1	24 3	
30	28 0	28 5	7 6	45	24 5	24 0	

Greenwich Time	dH	HdD	dV	Greenwich Time	dH	HdD	dV
$4^h 46^m$	24 2	23 5		$5^h 24^m$	16 1	17 4	
47	24 2	23 1		25	16 1	17 4	
48	23 8	23 0		26	15 5	17 2	
49	23 5	22 6		27	15 3	17 0	
50	22 9	22 0	8 0	28	15 2	17 0	
51	22 0	21 8		29	15 3	17 0	
52	21 8	21 5		30	15 2	17 0	10 0
53	21 8	21 3		31	15 2	17 0	
54	21 9	21 1		32	15 2	17 0	
55	21 9	21 0		33	15 3	17 0	
56	22 0	21 0		34	15 1	17 0	
57	21 7	21 0		35	14 9	17 0	
58	21 0	21 0		36	14 9	17 0	
59	20 6	21 0		37	14 7	17 0	
5 0	19 8	21 0	7 8	38	14 5	17 0	
1	19 5	21 0		39	14 2	17 0	
2	19 5	21 0		40	11 1	17 0	10 5
3	19 5	21 0		41	14 0	17 0	
4	19 6	20 8		42	13 7	17 0	
5	19 6	20 5		43	13 4	17 0	
6	19 5	20 5		44	13 2	17 0	
7	19 2	20 2		45	13 2	17 0	
8	18 8	20 0		46	13 1	17 0	
9	18 6	20 0		47	13 2	17 0	
10	18 3	19 6	7 8	48	13 0	17 0	
11	18 1	19 3		49	12 8	17 0	
12	17 7	19 0		50	12 7	17 0	10 5
13	17 3	18 9		51	12 4	17 0	
14	17 3	18 8		52	12 1	17 0	
15	17 3	18 7		53	11 8	16 9	
16	17 2	18 7		54	11 2	16 7	
17	17 2	18 8		55	11 0	16 6	
18	16 9	18 4		56	11 0	16 6	
19	16 8	18 4		57	11 1	16 6	
20	16 6	18 0	8 7	58	11 0	16 6	
21	16 6	17 7		59	10 9	16 6	
22	16 6	17 4		6 0	10 8	16 6	11 2
23	16 5	17 4		1	10 9	16 6	

Greenwich Time	dH	HdD	dV	Greenwich Time	dH	HdD	dV
$6^h\ 2^m$	10 9	16 6		$6^h\ 40^m$	10 2	9 1	12 0
3	10 9	16 6		41	10 3	9 1	
4	10 7	15 9		42	10 3	9 1	
5	10 2	15 4		43	10 4	9 1	
6	10 0	15 1		44	10 1	9 1	
7	9 9	15 2		45	10 3	9 1	
8	9 9	15 0		46	10 2	8 9	
9	9 9	15 0		47	10 5	8 6	
10	9 8	14 9	12 5	48	10 6	8 3	
11	9 9	14 7		49	10 6	8 0	
12	9 7	14 7		50	10 5	7 8	11 4
13	9 7	14 2		51	10 6	7 6	
14	9 7	13 7		52	10 4	7 5	
15	9 5	13 5		53	10 2	7 4	
16	9 2	13 5		54	9 8	7 3	
17	9 3	13 5		55	9 8	7 1	
18	9 3	13 5		56	9 8	7 1	
19	9 1	13 5		57	9 9	6 8	
20	9 1	13 3	13 9	58	9 9	6 7	
21	9 7	13 1		59	10 0	6 5	
22	9 7	13 1		7 0	9 9	6 4	10 8
23	9 6	13 1		1	10 1	6 3	
24	9 9	13 1		2	10 1	6 2	
25	10 5	13 1		3	10 1	6 0	
26	9 8	13 1	14 1	4	10 1	5 7	
27	9 7	13 1		5	9 9	5 6	
28	9 9	12 8		6	9 4	5 6	
29	10 2	12 5		7	9 0	5 6	
30	10 1	12 1	13 7	8	8 9	5 6	
31	10 6	11 7		9	8 9	5 6	
32	10 6	11 0		10	8 9	5 4	9 1
33	10 7	10 9		11	9 0	5 2	
34	10 7	10 3		12	9 0	5 1	
35	10 6	9 8		13	9 1	5 6	
36	10 1	9 8		14	9 1	5 6	
37	10 2	9 6		15	9 0	5 6	
38	10 1	9 4		16	8 8	5 4	
39	10 2	10 2		17	8 9	5 1	

Greenwich Time	dH	HdD	dV	Greenwich Time	dH	HdD	dV
$7^h 18^m$	8 8	5 1		$8^h 30^m$	— 9 3	7 8	17 0
19	8 8	5 1		9 0	—12 6	9 1	22 6
20	8 8	5 1	8 4	30	—16 3	10 3	28 9
21	8 9	5 1		10 0	—21 1	13 9	34 0
22	8 9	5 1		30	—19 5	15 2	35 1
30	2 7	5 0	8 3	11 0	—16 3	16 2	32 9
8 0	— 3 7	5 4	10 0				

On the plate the trace of the horizontal vector for *Karang Sago* on May 18 1901 and that for the period May 9—17 (scale 1 mm $= 0\ 2\ \gamma$) is inscribed (fig 1) Fig 2' gives the same for *Batavia* on the same scale and fig 2' on a scale of 1 mm $= 1\ \gamma$ Fig 3 gives the oscillation of the vertical intensity at *Batavia* on May 18 and the mean oscillation for May in the year of minimum sun spot frequency viz 1887

Finally the mean May vectordiagram for the period 1883—1899 for *Batavia* was inserted as figure 4

Let us first submit these figures to a closer examination The average curve described by the extremity of the horizontal vector at *Karang Sago* and at *Batavia*, deduced from the period May 9—17 fairly corresponds with that according to the May diagram 1883—1899 but for the fact that at *Karang Sago* the maximum morning elongation was not reached before 5 18 Gr time

The magnetogram for *Karang Sago* for May 18 shows that this maximum elongation was reached at about 4 0 Gr t on the given date while at 5 18 the descent had already set in as the movement of the needle slightly deflected from the normal course later on in the day it is for the present impossible to state what the undisturbed course would have been

Two ways of building up a hypothesis on this are open either two points lying on two rather undisturbed parts may be connected with each other — *in casu* those for 4 30 and 9 0 are the most expedient for this purpose — or the mean curve may be moved parallel to itself in such a way that the point for 5 18 shall coincide with the corresponding one for 5 18 of the course for May 18 If however there was an eclipse disturbance we must fear that the

one at 5 18 i e half an hour before the time of totality had made itself felt already For *Batavia* the difficulty is of less importance for here the curve between 4 30 and 5 30 is almost parallel to the mean one (May 9—17) and it is obvious that the thing to do is to make the points for 4 53 (12 0 Bat t) coincide It will then appear that the points for 8 0 again fall close to each other which all the more supports our hypothesis

With respect to the *Karang Sago* vector curve of May 18 the first thing that strikes us is the movement towards the west after 5 18 and its eastward change of direction at 5 45 in consequence of which a loop is formed

The secondary turning points for

horizontal intensity at	5 43
declination at	5 15
(totality at *Kar Sago*	5 38 — 14)

are obvious on the magnetogram

After this the movement towards the east continues in consequence of which a much larger loop is formed in which the direction of motion is reversed the maximum eastern elongation being reached at 6 55

From 8 0 to 8 30 the movement was pretty normal but after this another deflection towards the west sets in

The curve for *Batavia* where the middle of the eclipse occurred at 6 0 has a regular course till 5 30 after which however a decided westerly western deflection with increased depression of *H* shows itself changing a short time after 6 0 into an eastward movement with increase of *H* and stopping at 7 15 It will be noticed that the curve at 5 15 i e at the very moment when the striking loop movement alluded to above took place is quite smooth whereas it shows a slight irregularity at 6 15 (*Vide* table)

The first hypothesis made in order to explain these irregularities is that the westward movement and first loop at *Karang Sago* as well as the movement towards the west at *Batavia* were caused by the eclipse, that afterwards however a common disturbance set in bringing about the second loop at *Karang Sago* and the eastward deflection at *Batavia*

Looking at the variation curve for the vertical intensity at *Batavia* on May 18 together with the normal one (May 1887) we see that the course is a normal one till 5 10 after which time a decided deflection occurs following which in the direction indicated by the broken

line we first get an increase until 6 20 then a decrease until 7 35 and further an increase again

According to our first hypothesis the first increase may be ascribed to the eclipse the strong decrease to the second disturbance

From the American observations of 1900 BAUER concludes that some magnetic phenomenon attracting the north end of the needle and following the central shadow traversed the atmosphere

Let us imagine this phenomenon to be connected with a height H above the surface of the earth and to be above some point at a distance X from the station of observation The horizontal component of attracting force will then be

$$\frac{C X}{(H^2 + X^2)^{3/2}}$$

and, when approaching from a distance ∞ this component will first increase show a maximum when $X = \frac{1}{2} H \sqrt{2}$, decrease after that and become zero when $X = 0$ The vertical component will reach a maximum when $X = 0$

At the beginning the behaviour of the disturbance component at *Karang Sago* fully agrees with this hypothesis The first maximum was reached at 5 45, i e four minutes after the middle of totality

The distance at which the magnetic phenomenon follows the central shade is not known Considering however, that HELM CLAYTON [1] has found $\pm$ 500 miles $= \pm$ 15 minutes of time for the meteorological disturbance we may in this case agree upon a smaller distance as a matter of course, some few minutes will certainly come nearer the truth As a minimum we find 4 minutes here The rate of velocity of the central shade across *Sumatra* being 32 K M per minute we find $H =$ 226 271 and 317 K M resp with a lagging of 5 6 and 7 minutes

The vertical component, decreasing in the United States where the north pole is dipping must have increased in *Sumatra* where the south pole is dipping which is confirmed by the observations at *Batavia* It is to be regretted that the variations for the vertical force at *Karang Sago* are wanting, because they might probably have recorded the moment of the crossing of the magnetic phenomenon

[1]) H HELM CLAYTON, The eclipse cyclone and the diurnal cyclones *Annals of the Astr Obs of Harvard College* Vol XVIII p 1

As a counterpart to the first hypothesis drawn up in order to explain the variations of the magnetic force at *Karang Sago* and *Batavia* it is possible to make another in which the influence of the eclipse is assumed to have worked long afterwards and to have produced the second large loop at *Karang Sago* as also the east ward bend at *Batavia*

A close study of the material gathered by the different observing stations over the whole earth, will perhaps render it possible to decide between the two hypotheses

Observations during former eclipses

Not before the observation of an influence during several eclipses it will be possible to solve the problem in hand In view of the rareness of total eclipses it is of importance to take into consideration former observations as well

For this very reason I venture to call attention to a paper by the first director of the Batavia Observatory Dr P A Bergsma Magnetische waarnemingen gedurende de zonsverduistering van 12 Dec 1871 *Natuurkundig Tijdschrift voor Nederlandsch Indie* 1873

To begin with, Dr Bergsma mentions all that has been observed in connection with the question under consideration and from this historical compilation it appears that everything done before 1870 may be safely dismissed without further notice

In 1870 series of observations of the declination were made in *Italy* (solar eclipse of Dec 22 1870) viz at *Terranova*, (*Sicily* totality) *Naples* *Rome* *Livorno*, *Florence* *Bologna* and *Moncalieri*

Mr Diamilla—Muller the organizer and observer at *Terranova*, laid down his reports in the *C R* LXXIII p 575 and 1230 while he published the observations in full in a paper entitled *Eclisse totale del sole del 22 Dec 1870 Osservazioni meteoriche e magnetiche eseguite in Terranova di Sicilia Relazione di D E* Diamilla-Muller *e Luciano Serra Milano* R Treves 1872

Diamilla—Muller was of opinion that he had observed a very pronounced influence but in a sharp criticism Bergsma proves firstly, that Diamilla-Muller made the observations in a superficial way and interpreted them with a biassed mind secondly, that by mistake the scale value for *Terranova* was counted double

In 1871 Bergsma made some observations of the declination at *Batavia* and at *Buitenzorg*, and after a scrupulous examination was led to the conclusion that the Italian observations no more than those in *Java* proved the declination of the needle to be influenced by the solar eclipse

Below are given the declination values at *Terranova* (with corrected scale value) as western deviations from the most eastern reading for that place observed at 9 30 a m together with the deviations from the normal values at *Batavia* and *Buitenzorg* both during eclipse time The beginning of the eclipse at *Terranova* occurred at 0 41 the totality at 1 57 the end at 3 18 (loc time) At *Buitenzorg* these moments were respectively 9 6 10 29 1/2 and 0 5

Variations of Western Declination observed at *Terranova* (*Sicilia*), on Dec 22 1870

0h 0m	4 22	1h 14m	4′ 22	1h 58m	2 54
10	4 22	15	4 22	59	3 11
20	5 2	18	4 15	2 0	3 21
30	4 55	19	4 15	1	3 21
31	4 55	20	3 48	2	3 21
40	5 15	23	3 48	3	4 22
41	5 29	26	3 48	4	4 22
42	5 42	27	3 48	5	4 22
43	6 19	28	3 48	6	4 22
44	6 36	29	3 18	7	4 22
46	7 9	30	3 48	8	4 28
47	7 9	33	3 48	9	4 28
48	6 56	35	3 48	10	4 35
49	6 56	36	3 31	11	4 38
50	6 49	37	3 31	12	4 38
51	6 36	38	3 31	13	4 55
52	6 2	39	3 21	14	4 55
54	5 56	40	3 21	15	5 2
55	4 55	42	3 1	16	5 42
57	4 28	43	3 21	17	5 29
58	4 22	44	3 21	18	5 29
59	4 22	45	3 15	19	5 29
1 0	4 22	46	3 21	20	5 22
3	4 22	47	3 31	21	5 22
5	4 5	48	3 31	22	5 22
6	4 5	49	3 48	23	5 29
7	4 22	50	3 41	24	5 29
8	4 40	52	3 28	25	5 36
9	4 22	53	3 15	26	5 49
10	4 8	54	3 15	27	5 49
12	3 41	55	3 15	28	5 49

$2^h 29^m$	6 2	$2^h 50^m$	4 15	$3^h 25^m$	6 2
30	5 59	51	4 15	30	5 15
34	5 22	55	4 15	35	5 29
35	5 12	3 0	4 55	40	4 55
36	5 12	10	5 15	50	4 55
39	4 55	20	5 29	4 0	4 55
40	4 22				

Deviations of the normal values of the Declination observed on Dec 12, 1871

Batavia

	8^h	9^h	10^h	11^h	12^h
0	0 07 E	0'93 E	0 14 W	0 29 W	0 57 E
5	0 07	0 93	0 00	0 43	0 65
10	0 36	0 86	0 07	0 36	0 79
15	0 43	0 57	0 14 E	0 14	0 14
20	0 72	0 50	0 22	0 22	1 01
25	0 86	0 57	0 36	0 14	1 08
30	1 22	0 43	0 22	0 07	1 08
35	1 15	0 29	0 22 W	0 07 E	1 15
40	1 08	0 07	0 43	0 22	1 22
45	0 86	0 00	0 50	0 07	1 08
50	0 93	0 00	0 50	0 36	1 36
55	1 15	0 07 W	0 50	0 36	1 36

Buitenzorg

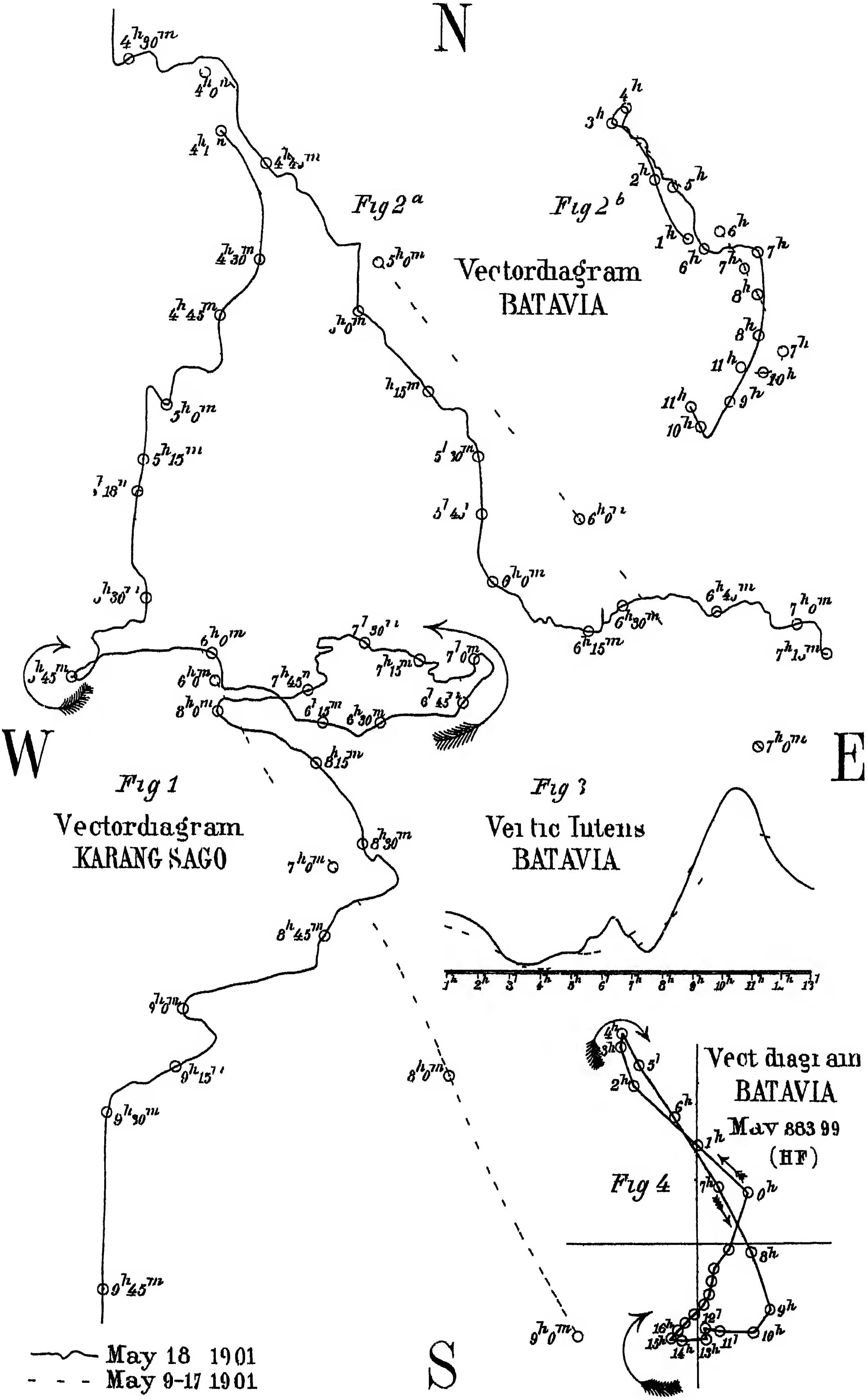
	8^h	9^h	10^h	11^h	12^h
0	0'32 E	1'02 E	0 32 W	0'06 W	1'02 E
5	0 19	1 02	0 00	0 00	1 02
10	0 45	0 89	0 06 E	0 06 E	1 02
15	0 51	0 77	0 26	0 06	1 38
20	0 70	0 64	0 32	0 38	1 34
25	0 89	0 70	0 57	0 45	1 40
30	1 40	0 15	0 57	0 38	1 34
35	1 21	0 26	0 32	0 38	1 28
40	1 15	0 26	0 06 W	0 51	1 28
45	1 02	0 13	0 06	0 70	1 34
50	1 02	0 00	0 06	0 77	1 40
55	1 15	0 19 W	0 13	0 70	1 47

At *Terranova* the day of the eclipse was not magnetically quiet After the first contact the needle moved towards the west but after a quarter of an hour the movement went towards the east and the maximum eastern deflection was reached a few minutes before the time of totality Afterwards the needle moved towards the west performed another movement towards the east and finally occupied a western maximum at the last contact

During eclipse time at *Batavia* and *Buitenzorg* the needle performed a movement of about one minute and a half of arc towards the west which was however interrupted by a partial retrogression towards the east lasting from half an hour before the middle of the eclipse to half an hour after The transition from the movement towards the east to a movement towards the west took place a few minutes before the middle

Consequently it can scarcely be avoided to conclude that in *Sicilia* in 1870 and in *Java* in 1871 during the eclipse a movement of the needle was observed the reverse of which was observed at *Karang Sago* and at *Batavia* in 1901

Batavia, August 1901


N
W
E
S
Fig 1
Vectordiagram
KARANG SAGO
Fig 2 a
Fig 2 b
Vectordiagram
BATAVIA
Fig 3
Vertic Intens
BATAVIA
Fig 4
Vect diagram
BATAVIA
May 883 99
(HF)
May 18 1901
May 9-17 1901

TOTAL ECLIPSE OF THE SUN,

May 18, 1901

Reports on the Dutch Expedition

TO

KARANG SAGO, SUMATRA

Published by the Eclipse Committee of the Royal Academy, Amsterdam

No 3 POLARIMETRIC STUDY OF THE CORONA

No 4 HEAT RADIATION OF THE SUN DURING THE ECLIPSE

BY

Dr W H JULIUS

TOTAL ECLIPSE OF THE SUN,
May 18, 1901

Polarimetric Study of the Corona

BY

W. H. JULIUS.

It has been ascertained by many observers that the light of the Corona is partially polarized in planes, passing through the centre of the Sun, but as to the percentage of polarized light issuing from the different parts of the corona only very little is known.

We, therefore, decided to take advantage of the exceptionally long duration of this eclipse by making a quantitative study of the state of polarization in as many well determined points of the corona as could be investigated within the six minutes of totality.

The plan adopted was, to direct a double image polarimeter (of the CORNU pattern, slightly modified) on different points of the coronal image, formed by a telescope. A refractor of STEINHEIL SCHRODER (belonging to the Leiden Observatory) with an object glass of 10,8 c. m. diameter and 275 c. m. focal distance was available for the purpose. The eye-piece was replaced by the polarimeter piece, which had been constructed after my design by Mr. G. KOOLSCHIJN, mechanician of the Physical Laboratory of the Utrecht University, so as to answer the following conditions.

While the centre of the image of the eclipsed Sun was kept on the optical axis of the telescope (by a device to be described below), it should be possible first to select a proper point of the coronal image and to read its position, then quickly to adjust the polarimeter for measuring the degree of polarization in a radial plane at the selected point, the whole operation taking less than half a minute.

This end has been attained by mounting the polarimeter *PP* (Plate I, fig 1) on a slide *S* so as to allow its optical axis to be moved parallel to itself in a plane, containing the optical axis of the telescope The slide *S* moves between the rulers *T* and *T* (fig 2) which are screwed on a circular plate *A* with two projecting parts a_1 and a_2 These parts bear by means, respectively of a spiral spring *s* (Plate I, fig 1) and of an adjusting screw *t* on the corresponding projecting parts b_1 and b_2 of the stout brass ring *B* At right angles to the line b_1 b_2 two nuts b_3 and b_4 (cf fig 2) protrude from *B*, they sustain the plate *A*, clasping it between two pointed screws By working the adjusting screw *t*, a small inclination may thus be given to the optical axis of the polarimeter (in order to make it catch the light from the central parts of the objective even when it is placed in a very eccentric position)

The ring *B* fits into the strong ring *C* with a conical tap allowing it to be turned round easily and, when required, to be fixed by means of the pressing screw *D* *C* is soldered to a short tube *E* having a lock-ring *F* by which it is fastened to the telescope tube An index engraved on *C* serves to indicate the position of the ring *B* which is divided into degrees For reading the distance between the optical axis of the polarimeter and that of the telescope a millimeter scale with nonius (not shown in the figures) is provided on the slide The latter is moved with rack and pinion, *B* is revolved by hand By these means it is easy to fix the axis of the polarimeter on any point of the corona, to read the position angle and the radius vector of that point, and then to determine the degree of polarization in the radial plane, in fact, the principal plane of the polarizer, if once set perpendicular to the slide, will be perpendicular to the radial plane in any position

The polarimeter consists of the following parts The polarizer is a plane parallel plate of Iceland spar *I* one centimetre thick, giving two images one millimetre distant from each other This spar has been substituted for the Wollaston prism of the original Cornu polarimeter, because the combination of the instrument with a telescope required the two polarized beams not to diverge It is mounted in the end of a tube *M* fitting

with strong friction into the tube N which is fastened on the slide The other end of M carries an index, under which the divided circle of the analyzer (a GLAN prism G) can be revolved The principal plane of the spar plate I being adjusted perpendicular to the direction in which the slide moves, we see the extraordinary image always shifted at right angles to the Sun's radius

In the focal plane ff of the telescope a screen is provided, which can be moved by means of the crank H round the axis x and which has two openings to be used alternatively (cf fig 2) One is a square hole h, of 1 m m side, the other a circular glass window w, of 1 c m diameter in the centre of which a square millimetre is engraved Either of the squares will occupy exactly the same place in the centre of the field of the polarimeter when the crank is pushed against one of two accurately adjusted stops by which the movability of the screen is limited An enlarged double image of the opening is seen through the lens L

The procedure with the instrument is as follows

An assistant is charged with keeping the centre of the eclipsed Sun in the axis of the telescope by the aid of a special finder and a setting arrangement (cf below) He also reads the position of the circle B after every setting made by the observer Each separate observation begins with putting the glass window into the central position and the principal plane of the analyzer parallel to the slide, thus allowing only the ordinary image to pass, and a considerable portion of the phenomenon to be seen at once Now the observer works the pinion of the slide and turns the ring B until the small engraved square includes the region of the corona where the polarization is to be measured, then he reads the position of the slide, and, by pushing the crank, he substitutes the square hole for the window The analyzer is now turned until the two images of the hole (which are exactly in contact along one side) show equal intensity If it has to be turned through an angle α, the proportion of the polarized to the total light is given, according to the theory

of the instrument, by $\cos 2\alpha$ [1]). A second assistant notes the three scale readings and the remarks made by the observer. Then the crank is pushed back against the first stop and another observation prepared.

The adjustment of the centre of the total phenomenon in the centre of the telescope field should, of course, not be interfered with by manipulating the polarimeter. Accordingly, the eye end of the telescope was kept in position by means of two drawbars of adjustable length. One of them connected the eye end to a remote point of the very long hour axis [2]), thus fixing the telescope in the desired declination, the other joined it to a fixed point which was selected so as to permit the daily motion to be followed by gradually altering the length of that bar. To perform this, the crank of a simple gear had to be turned round about once a second. The assistant, charged with this manipulation, controlled his setting by continually observing the position of an image of the eclipsed Sun, this image was formed by a finder lens, of 2.6 m focal distance, on a white screen, and had to be kept there concentric with a circle, drawn with a radius slightly exceeding that of the Moon's image. By this method the Moon's centre instead of the Sun's centre was adjusted in the optical axis, but the relative motion of the two centres being known, the scale readings could be corrected accordingly.

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[1]) If we denote by i_o the intensity of the ordinary beam leaving the spar plate by i_e the intensity of the extraordinary beam then the ratio of the polarized to the total light issuing from the considered part of the corona is given by

$$\frac{i_e - i_o}{i_e + i_o}$$

Now, if the principal plane of the analyzer makes an angle a with the slide the intensity of the transmitted part of the ordinary beam will be proportional to $i_o \cos^2 a$ of the extraordinary beam to $i_e \sin^2 a$ and the setting consists in making these intensities equal

$$i_o \cos^2 a = i_e \sin^2 a$$

Hence

$$\frac{i_o}{i_e} = tg^2 a$$

$$\frac{i_e - i_o}{i_e + i_o} = \cos 2a$$

[2]) The parallactical mounting of the telescope was of the English pattern the declination axis being attached in the middle of a long frame forming the body of the hour axis, which rested on two masonry piers having a distance of 3,20 m.

Lieutenant T J VAN DER ESCH, who was in charge of the polarimeter has succeeded in making eleven observations during totality

This very satisfactory result could not have been obtained without having practised under conditions similar to those prevailing during the eclipse Dr J P VAN DER STOK had kindly suggested the construction of an artificial corona for the drills This was easely accomplished with the assistance of a mechanician of our man of war *Sumatra*

Two iron hoops one of 80 and the other of 20 c m diameter, were joined together by several straight iron rods each 60 c m long, so as to form a stunted cone (Plate I, fig 3) A smooth conical surface was obtained by coating the inside with white card board *M* indicates a black disk of 25 c m diameter, representing the new moon, and supported by two strong wires, not visible in the figure Behind it was a small incandescent lamp *L*, which illuminated the conical surface

When the apparatus was placed at a distance of 2821 c m from the objective of the telescope and the tube drawn out correspondingly, an image of the black disk exactly equal to that of the moon on the day of the eclipse (2,702 c m diameter) was formed on the screen of the polarimeter The dark image was surrounded by an aureole of light partially polarized in radial planes, very much like the corona By painting black streaks on the bulb of the incandescent lamp the coronal streamers could be roughly imitated and the proportion of polarized light was varied by locally covering the conical surface with pieces of paper of different colour and reflecting power [1])

After some practice it was possible to make, on the artificial corona, 12 complete observations within 6 minutes The results could, of course, be controlled afterwards at ease The probable error of a quick setting of the analyzer proved to be almost 1°, during the eclipse it may have been somewhat greater in consequence of the less comfortable position of the observer

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[1]) Another arrangement for producing an artificial corona has been described by R W WOOD, Nature 63 p 250 (1901)

A few minutes before the beginning of totality, as well as a few minutes after the end, the diffused light of the sky round the Sun (at a distance of about one diameter from the limb in the directions North East, South, West) was analyzed in order to decide whether any atmospheric polarization could be detected The result was negative

In the following table we give the readings made by Mr VAN DER ESCH and his assistants during totality, together with the results derived from them The position angles are counted from North through East, the radius of the Moon's image is 13,5 m m Fig 4 shows the positions of the points chosen

TABLE

Nr	Position angle	Radius vector	Reading of analyzer a	Proportion of polarized light $\cos 2a$
1	218,5°	15 mm	38°	0,242
2	218,5	20	34	0,375
3	145	14	37,5	0,259
4	155,5	15	43	0 070
5	136,5	22,5	45	0,000
6	73,5	15	38	0,242
7	73,5	20,5	42,2	0,098
8	73,5	22 5	45	0,000
9	48	14	38,2	0,237
10	48	18	34	0,375
11	48	24	44	0,035

It appears from these numbers that the light of the corona is more strongly polarized at a certain distance from the Sun's limb than very near to it At still greater distances the polarization decreases again A similar result has been obtained by PERRINE [1]) That the observation Nr 4 has given a smaller proportion of polarized light than Nr 3 may have been caused by the fact that in the former case the pointing was made on one of the dark rifts A certain disturbing influence, which

[1]) Astroph Journ XIV, p 354 (1901)

we are now going to discuss, might however also be responsible for this discrepancy

As light clouds and haze were continually veiling the phenomenon, the question arises, how far this may have influenced the results obtained Clouds might have an appreciable depolarizing effect on the transmitted light

In order to get some idea regarding the probable magnitude of such an influence, I made the following experiment

Into a horizontal glass tube, 122 c m long, 8 c m wide, and closed with plate glass at both ends, some cigar smoke was blown through a side tube As the enclosed air was kept saturated with water vapour (the tube being moistened inside), a fog could now easily be produced or dissolved by suddenly diminishing or raising the pressure In most of the experiments the density of the fog was such, that a parallel beam of light travelling through the tube, lost more than 0,9 of its original intensity by diffusion

A diaphragm with a circular opening was placed in front of the condensor of an arc lamp, and an image of the opening was focussed, through the glass tube, on the screen (with the square hole) of the polarimeter that had been used in the eclipse The image and its surroundings could be examined just as had been done with the corona

If the incident beam was totally polarized by means of a Nicol prism, and the fog alternatively produced and dissolved this did not affect the polarization of the image of the opening in any appreciable way Indeed, from a great number of settings I came to the conclusion that, if in the transmitted light a component polarized at right angles to the original plane of polarization might have been present, its intensity could not have exceeded 0,0001

It is, therefore, not probable that the condition of polarization of a directly transmitted beam of light should suffer any change from thin clouds

But the clouds may have exercised a disturbing influence on the observed polarization of the corona in a somewhat different way

In the above mentioned experiment the light diffused by the haze and surrounding the direct image, has also been studied, it proved to have preserved complete polarization in the same plane

Now, at a point *a* in the image of the corona we meet not only with the light coming from the corresponding region *a* of the corona itself but also with light, diffused by the clouds, and issuing from other places *b* *c* *d* of the corona This diffused light brings with it, according to our experiment, the polarization belonging to *b*, *c*, *d* and will, therefore, in the point *a* *of the image* exercise an influence which we may call depolarizing

It stands to reason that among the rays coming to *a* by diffusion those will prevail, wich proceed from the nearest surroundings of *a* and whose planes of polarization therefore differ only very little from that of *a* A sensible change in the state of polarization can only occur when even remote parts of the corona contribute in a perceptible measure to the diffused light at any point of the image So we must try to estimate the intensity of the diffused light at different angular distances from a central beam

Some of the photographs of the corona, secured by our expedition, correspond to the moment of third contact The point where the first ray of direct sunlight became visible is there surrounded by an aureole of diffused light The distribution of the intensity in that aureole gives us some idea of the proportion of diffused light in various distances from the direct beam It shows that, assuming conditions similar to those which prevailed at the moment of third contact, the influence of distant parts of the corona on the polarization observed at any selected point must have been small At some epochs during totality it may have been greater, but, when considering the whole series of photographs of the corona, we get the impression that the clouds have not materially disturbed our polarimetric results

TOTAL ECLIPSE OF THE SUN,

Mai 18, 1901

Heat Radiation of the Sun during the Eclipse

BY

W H JULIUS

Considering the elementary state of our knowledge of the proportion in which the radiating power of the Sun is distributed over the disc and its surroundings, we decided to confine ourselves to integrating observations, leaving a detailed study of the coronal heat radiation for future research

Our principal aim, therefore, was to find the ratio of the total heat emitted by the corona to that emitted by the uneclipsed Sun

Attempts to detect the solar corona in full sunlight by means of its heat radiation have been made by M DESLANDRES and by Professor HALE with contradictory results [1]) The evidence obtained by the latter, that the intrinsic heat radiation (for unit surface) of the corona must be very small even in comparison with that of the Moon, was confirmed by Mr ABBOT's observations during the eclipse of May 1900 [2])

The method

In the arrangement used by Mr ABBOT the rays were concentrated upon a bolometer strip after having suffered seven reflections by silvered mirrors It seemed to me desirable to control this method by another one in which mirrors as well as lenses and prisms were wholly dispensed with in order that no possibility might be left for attributing any heating effect observed during totality to the proper radiation of an optical

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[1]) DESLANDRES Astroph Journ 12, p 366 HALE ibid p 372

[2]) ABBOT, Astroph Journ 12 p 71 LANGLEY The 1900 Solar Eclipse Expedition of the Astroph Oservatory of the Smithsonian Institution Washington, 1904 p 22

train, which might have received direct sunlight shortly before

So I fixed on the very simple plan of exposing the heat measuring instrument directly to the Sun, without any concentration of rays

This method allowed, besides, of an almost continuous measurement of the total solar radiation during the whole eclipse, from the first till the fourth contact which was not a small advantage Indeed, the exact shape of the uneclipsed part of the Sun's disc being known for every instant on which a heat observation was to be made, it would be possible to employ the whole series of observations for calculating the intensity of the radiation proceeding from the successive concentric zones of the disc It is true that the distribution of the heat radiating power all over the solar disc has already been studied in full sunshine by exploring the image with a thermopile or a bolometer, but we must not forget that in those investigations the results may have been disturbed by atmospheric radiation dispersion and diffraction If, on the other hand, the Moon acts as a screen, the disturbing or rather levelling influence of our atmosphere must be less, especially during the observation of narrow crescents For this reason the curve, representing the varying intensity of radiation during the whole eclipse, would yield very valuable data for determining the emissive power of the various zones of the disc

Several reasons, which I shall not now discuss, led me to prefer the thermopile to the bolometer as a heat measuring instrument in the present investigation

The thermopile had to be mounted in such a manner that the following two conditions were fulfilled 1st that each part of the sensitive surface should receive rays from all the parts of the source under investigation, and, 2dly, that no other source of radiant heat should in any way affect the galvanometer readings

Accordingly, the circular sensitive surface (with radius r) was fixed into one end of a long tube containing a set of diaphragms with increasing openings, the last one having the radius R (Plate II, fig 1) All radiating points lying within the conical space Ω shine upon the whole surface πr^2, each point

lying within the annular conical space $\Omega - \Omega$ sends its rays only to a part of the sensitive surface The joint action of the latter points on the instrument will not be proportional to the total radiation proceeding from them, for if the same sources, preserving their distances from the pile, were distributed otherwise within the annular space, their effect would be different As we want indications that are proportional to the total radiation of the entire phenomenon, we must take care that this be wholly situated within the conical space Ω and, moreover, that $\Omega - \Omega$ be small as compared with Ω, lest disturbing sources of radiation might happen to be present in the annular space Sources lying outside Ω can do no harm, provided the tube with the diaphragms and the cover of the thermopile are well shielded and at uniform temperature

It is easy to express the ratio $\frac{\Omega - \Omega}{\Omega}$ in terms of r and R Indeed (cf fig 1),

$$\Omega = 2\pi\,(1 - \cos\,\Delta)$$

$$\Omega = 2\pi\left(1 - \cos\,(\Delta + \delta)\right)$$

$$\Omega' - \Omega = 4\pi\,\sin\left(\Delta + \frac{\delta}{2}\right)\sin\frac{\delta}{2}$$

Δ as well as δ being less than 2°, we may put

$$\Omega - \Omega = 2\pi\,\delta\,\Delta + \pi\,\delta^2$$

$$\Omega = 4\pi\,\sin^2\frac{\Delta}{2} = \pi\,\Delta^2,$$

hence

$$\frac{\Omega - \Omega}{\Omega} = \frac{2\,\delta}{\Delta} + \left(\frac{\delta}{\Delta}\right)^2$$

so δ should be taken much smaller than Δ

Now, if through the centre of the sensitive surface we draw a line parallel to PQ, we immediately see that

$$\Delta = \frac{R - r}{PQ}, \qquad \delta = \frac{2\,r}{PQ},$$

and, therefore

$$\frac{\Omega - \Omega}{\Omega} = \frac{4\,r\,R}{(R - r)^2}$$

In our apparatus we made $r = 2{,}5$ mm, $R = 40$ mm, hence

$$\frac{\Omega - \Omega}{\Omega} = 0{,}284, \qquad \frac{\Omega}{\Omega} = 1{,}284$$

The two cones Ω and Ω will cut the celestial sphere in circles

whose radii are in the ratio $\sqrt{\Omega}\ \ \sqrt{\Omega} = 1{,}133$ This is represented in fig 2 on Plate II, the broken circle being the boundary of the field Ω from which every point radiates to the *whole* sensitive surface, and the continuous circle showing the limit beyond which no object can send rays to any part of that surface The diameter of the field Ω has been chosen 3° ($\Delta = 1^1/_2°$), thus, when the Sun is in its centre, the field may be taken to embrace the whole of the efficient corona, whilst no effective sources of radiation lie within the annular space $\Omega - \Omega$ Accordingly the heat received will be proportional to the total radiation of the phenomenon

Description of Apparatus

In fig 3 (Plate II) the tube (which was mounted parallactically) is represented in the right proportions at scale 1 to 10 The inner tube is made of copper in order to favour equalization of temperature It is provided with 8 brass diaphragms highly polished on the side facing the incident light and blackened on the back-side The copper tube is envelopped by a layer of felt, 15 m m thick, then comes a zinc tube, then a layer of cottonwool and finally a thin tin-plate coating The upper end of the zinc tube carries a system of two flat rings of aluminium, A_1 and A_2, joined together by three ebonite rods the first ring shields the other one from direct sunlight and the system serves to protect the outside of the tube against radiation if the axis should not be directed exactly on the Sun Between the aluminium rings is a moveable screen or shutter, consisting of 3 isolated aluminium plates and fastened to one end of a lever, the other end carrying a counter poise By working the head of the rod R the lever may be turned between two stops and thus the inside of the tube exposed or screened

The details of the thermopile P are visible in figures 4 and 5 which show in $^3/_4$ natural size the back sight and a cross-section of the piece fitting the lower end of the copper tube The pile consists of eight elements arranged in a circle They were constructed as follows The thermo-electric alloys used

are 97 $Bi + 3\ Sb$ and 94 $Bi + 6\ Sn$[1]) Very thin (0,05 m m) plates of these alloys, obtained by pouring the molten metal on plate glass were cut into the shape of small triangles with a basis of 2 m m and height 4 m m Two triangles forming a couple were soldered with their bases to the ends of two copper wires kept in position by the small ebonite block *e* and a bead of shellack *s* This little frame was pinched by a screw between the brass block *b* and the brass plate *c*, from which it was electrically isolated by two thin sheets of paper The tops of the two triangles were soldered with a microscopical bit of WOOD's metal on a small sector of silver plate, blackened at the other side, which formed part of the exposed surface

By this arrangement several advantages were obtained The pointed shape of the alloys serves to reduce the conduction of heat from the exposed to the shielded junctions, and the heat which reaches the latter is quickly removed through the copper wires to the brass body of the instrument Both circumstances join in increasing the difference of temperature between the junctions for a given intensity of radiation, i e the sensitiveness Owing to shape size and materials of the parts to be heated, the stationary condition of temperature is attained within a few seconds Moreover, the arrangement permits the testing of the electrical properties of each couple at any time *in situ* and in case of accident to remove and repair an element without danger to the rest

The copper wires of the successive elements are soldered together and the terminals of the pile connected to the copper blocks Q_1 and Q_2 Of course, the utmost care has been taken to avoid thermoelectric action in all other parts of the circuit, including the galvanometer and the resistance coils In figures 4 and 5 we see the stout brass plate B on which the eight elements are mounted, and which is provided with an ebonite ring E serving to protect it from being too much heated by the observer's hands during the preliminary manipulations Fig 5 shows, besides, the cover C protecting the thermopile and the cylindrical box D which is screwed on B and fits the

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[1]) HUTCHINS Am Journ of Sc 48, p 226—230, 1894

large copper tube T Between the bottom of this box and the thermopile a small tube with diaphragms is inserted The opening O in the bottom may be covered with a thin plate of rock-salt or fluor-spar when there are troublesome air-currents or otherwise kept entirely free The shielding of the thermopile from external influences is completed by a thick layer of cotton wool and a covering box of zinc, through which only the wires leading to the pile have free passage [1])

It was decided that during totality the axis of the instrument should be directed in succession to four points of the sky, situated to the North East, South and West of the Sun all at a distance of 3° from the disc, and that between each two of these exposures the axis should again be pointed towards the centre of the Moon In order to allow the required settings promptly to be made, a finding arrangement, consisting of a lens L and a white cardboard screen S, was attached to the tube On this screen five circlets were marked, in which the assistant had successively to catch the image of the corona by moving the tube

For measuring the thermoelectric currents a galvanometer of Du Bois and Rubens, with magnetic shielding and specially constructed for use in the tropics, has been employed A millimeter scale s (fig 6) on plate glass, 1 meter long was placed at a distance of 6,40 meter from the needle system and brilliantly illuminated by strips M of a large concave mirror throwing images of a petroleum flame f through the scale on the galvanometer mirror The readings were made with a telescope placed near the galvanometer The observer had the resistance boxes and keys close at hand and was able to check the sensibility of the galvanometer whenever required

Fig 7 is a diagram of the connections By means of the key K_1 (which was carefully kept at a uniform temperature) the galvanometer might be put either into the gauging circuit or into the circuit of the thermopile The resistance of the galvanometer was 3,6 ohms, with $^1/_{400}$ volt and 20000 ohms,

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[1]) The instrument has been constructed by Mr G Koolschijn mechanician of the physical laboratory of the Utrecht university

as in the diagram, it gave 300 scale divisions on the eclipse day, the complete oscillation period being 15 seconds. This has been taken as the normal condition of sensibility, it corresponds to a deflection of one millimeter for 4×10^{-10} ampere. All observations made on former days with other positions of the adjusting magnets have been reduced to this normal sensibility. Of the two needle systems belonging to the galvanometer the heavy one was used for the sake of steadiness. The resistance box R, put in circuit with the thermopile, was of the decade type with moving arms, the utmost care had been taken to keep it at a uniform temperature. When full sensibility was required, a copper plug was inserted between the copper pieces c and c, thus reducing the whole resistance of the circuit to 8,2 ohms (galvanometer 3,6, pile 4,34, wires 0,25). When, on the other hand, the effect of full sunshine at noon had to be recorded, it was necessary to insert $R = 30000$ ohms, then deflections of more than 500 millimeters were still obtained.

I had expected that the rocky ground of Sumatra's West coast would be steady enough to make antivibration precautions superfluous. But the soil of our eclipse camp was sandy and only 200 to 300 meters distant from the shore, so the stately rollers of the Indian Ocean, though not influencing to any appreciable degree the steadiness of our astronomical instruments, proved to be detrimental to our obtaining accurate galvanometer readings. On a surface of mercury, placed anywhere in or near the camp, a slight but almost continual rippling was observed, in which the periodical arrival of breakers on the coast could be distinguished. 500 meters farther from the shore was the nearest offset of the mountains, a thickly overgrown rock, 55 m high. On its summit the mercury appeared perfectly calm but the ascent was too difficult and the distance from the camp too great to have a part of our expedition settled there.

An antivibration apparatus had, therefore to be constructed with wood and rattan so as to answer as far as possible the theoretical requirements [1], it was suspended by three steel wires

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[1]) W. H. JULIUS. Ein Apparat für erschütterungsfreie Aufstellung. Zeitschr. für Instrumentenkunde 16, S. 267. 1896.

from the top of a strong bamboo frame, 4 m high The arrangement proved very satisfactory On Plate I of the „General Account" (Reports of the Dutch Expedition to Karang Sago N° 1) the hut with the galvanometer and accessories is indicated by *n*, the tube with the thermopile by *m*

Some idea of the efficiency of our thermopile may be got from the following experiments The instrument was pointed horizontally at some distant underwood having a temperature of about 29° This gave the zero reading Then, if at 7 m distance from the pile a person put his head in the way of the beam, a deflection of + 15 scale divisions was observed, although the temperature of the body exceeded that of the landscape by a few degrees only A piece of ice (some 150 gram) at 7 m distance produced a deflection of — 11 divisions if it was shaded, and of + 5 divisions if it was exposed to sunlight so as to reflect a little of it into the tube Pointings on the zodiacal light gave no positive results, but when directing the pile upon the nocturnal sky, a difference of 40 scale divisions was observed between altitudes 5° and 30° Observations of the latter kind, if systematically carried on, might perhaps lead to some valuable results regarding atmospheric radiation

Results

The following table contains the data of the observations of solar radiation, made on May 6, 14, 15 16 and 18 The first column gives the time of the observations and some remarks on the condition of the sky In the second column is indicated the total resistance of the galvanometer circuit, in the third the deflection produced by a current of $^1/_8$ microampère, as measured just before beginning a set of observations and controlled at the end of it Each deflection recorded in column 4 is derived from 3 readings screen, exposure, screen The assistant who was in charge of keeping the thermopile in the right direction by the aid of the finding arrangement, worked the shutter of the tube at the signals „open" and „shut" given by the observer at the telescope At the signal „open", the time was read by a second assistant During the partial phases of the eclipse the

observer had occasionally to vary the resistance of the circuit Time, resistance and readings were written down by a third assistant The fifth column, finally, contains the „reduced deflections", calculated for sensibility 300 and resistance 8 These numbers may be considered proportional to the heat received, as was confirmed by experiments made at home and by the fact that they actually were in the known proportion of 80000 to 1 for settings on the Sun and on the full Moon

TABLE I

Time			Resistance	Sensibility	Deflection	Reduced deflection
May 6				199,5		
(clear)	7^h	58^m	20000 Ω		388	1457000
	8	1			392	1472000
		3			395	1484000
		4			396,5	1490000
		5			396	1488000
		8			403	1515000
	9	11			429	1611000
		13			428,5	1609000
		15			436	1639000
		17			441	1658000
		19			444	1668000
		21			441,5	1660000
		23			444	1668000
		25			441	1658000
	10	11			465	1747000
		13			484	1819000
		17			470	1766000
		19			469	1761000
		21			469,5	1764000
		23			475	1784000
	11	44			517	1941000
		46			489	1837000
		48			475,5	1786000
		50			485	1823000
		52			483	1815000
		54			499	1875000
		56			499	1875000
		58			504,5	1895000
	12	0			506	1902000

Time		Resistance	Sensibility	Deflection	Reduced deflection
May 14			260		
(hazy,	9h 42m	20000 Ω		457,5	1319000
light clouds)	44			443,5	1279000
	45			447,5	1290000
	47			435	1254000
	50			440	1268000
May 15			235		
(rather	9 51 0s	20000		504	1588000
clear)	53 25			511	1610000
	57 2			517	1627000
	58 31			516	1624000
	10 1 4			523	1646000
	3 3			524	1650000
	5 4			507	1595000
	8 6			496,5	1562000
	24 53			534,5	1681000
	26 42			549	1729000
	28 43			543	1710000
May 16			330		
(no clouds,	12 24 37	20000		723	1642000
but hazy)	26 34			675	1534000
	27 56			717	1627000
May 18			300		
(clouds)	10 38 57	30000		331	1241000
	40 54			450	1687000
first contact	46 10			470	1762000
	51 56			354	1326000
	54 8			215	806500
	57 27			330	1237000
	59 3			342	1282000
	11 0 52			231	866000
	4 29			90	337500
	6 43			221	829000
	9 56			132	495000
	11 53	20000		158	395000
			298		
	18 22			201	506000
	21 42			142	357200
	23 57	10000		338	425000
(thick clouds)					
	43 42			45	56600

Time	Resistance	Sensibility	Deflection	Reduced deflection
11h 45m 57s			142	178600
47 28			44	55400
51 25			3,5	4400
12 2 3	2000 Ω		31	7800
3 41			—0,5	0
6 7			10,5	2640
12 6	400		9	455
13 46	100		76	956
15 20			143	1800
12 16 47			183	2300
18 54			48	604
begin of totality		Scale reading on corona	Scale reading near corona	
12h 19m 56s				
21 0	8 2	257		
21 20			N 250	—8,5
21 40		260		
22 0		272		
22 20			S 270	0
22 42		268		
23 5		270		
23 26			W 268	—7
23 50		280		
24 39		274		
24 59			E 272	0,5
25 20		269		
end of totality		Sensibility	Deflection	
12h 26m 18s		298		
31 54	2400		130	39250
33 17			131	39550
34 40			246	74300
36 13			291	87800
37 57			533	161000
40 3	10000		177	222700
41 17			183	230200
42 48			219	276000
44 21			31	39000
47 23			12,5	15700
50 31			9,5	11900
56 32			9	11300
58 2			11	13800
1 5 44			12,5	15700
12 3			> 500	> 600000

On Plate III the results are plotted down. Even on a clear day like the 6^{th} of May the march of the radiation with the Sun's altitude was not quite regular, probably on account of invisible haze, but most times the sky was nebulous or partly overcast, which made the heat observations a rather tedious work. Indeed, very favorable conditions for measurements of this kind could not have been expected near the sea in the tropics.

On the morning of the 18^{th} very discordant deflections were obtained, clouds continually passing before the Sun. During the time between the first and the second contact only 25 determinations of radiation were made at moments when the clouds were not too thick. At $10^h\ 45^m$, shortly before the first contact, the Sun had been shining through a perfectly clear patch of the sky, making the radiation reach its normal value of May 6^{th} at the same hour of the day. This is fully confirmed by the results obtained with the pyrheliometer (cf. below), for at the epochs $10^h\ 40^m$, $10^h\ 45^m$ and $10^h\ 48^m$ the indications on the milliammeter of the latter instrument were respectively 97, 101, 94,4, the number 101 corresponding exactly to what was found between 10 and 11 o'clock on a clear day.

The diminution of the Sun's total heat radiation during the partial phase, which in case of clear weather could have been registered by almost continual observation, now of course failed to reveal any law. At $12^h\ 18^m\ 54^s$, i. e. 62^s before second contact, a reduced deflection of 604 was still produced through the clouds.

After the beginning of totality the shutter of the thermopile was permanently kept aside and the instrument was directed in succession to four points of the sky, situated to the North, East, South and West of the Sun, each at a distance of 3° from the disc, but between each two of these exposures the corona was returned to the centre of the field and two readings were made on it. During all these operations light clouds were continually passing, leaving, however, the corona visible from time to time. This accounts for the very irregular indications from which we can only infer that the total radiation of the corona cannot have been larger than the observed differences

between the radiation of neighbouring groups of clouds, and is probably much less than that of the full Moon which, in a clear sky, would have caused a deflection of 23 or 24 scale divisions

The reduced deflections which were obtained from $12^h\ 2^m\ 3^s$ until $12^h\ 30^m$ are once more plotted on the diagram on a hundred times larger scale (see the dotted line) Even on this scale the heating effect during totality is too small to be represented Very striking is the rapid increase after third contact

Between $12^h\ 26^m$ and $12^h\ 43^m$ the surroundings of the Sun were comparatively clear, so that the corresponding points in the diagram may not be far from giving a part of the real radiation curve Then clouds came on again and the observations were discontinued at $1^h\ 12^m$, as it appeared hopeless to wait for any more trustworthy ordinates

The broken line is intended to give an idea of the curve, the true form of which ought to have resulted from our observations Owing to the unfavourable condition of the sky we have missed this end as well as the aim of finding the order of magnitude of the total heat radiation proceeding from the corona The disappointment caused by this failure may serve as an excuse for having delayed the publication of the report so long

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Observations with the Pyrheliometer

In order to convert the results obtained by the thermopile into absolute measure, we intended to make simultaneous observations with Angström's electrical compensation pyrheliometer [1]) during the partial phases of the eclipse so long as the heat radiation would be sufficiently intense From preliminary observations made with this instrument on several dates preceeding the date of the eclipse it appeared that, in the tropical coast region where we stayed, even on comparatively clear days the heat radiation is to a considerable extent absorbed by the atmosphere Indeed, the number of gram-calories per minute per square centimeter very seldom exceeded the value $Q = 1{,}25$,

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[1]) Knut Angström Wied Ann 67 S 633—648

whilst at Teneriffe, at a small elevation above the level of the sea, ANGSTROM found $Q = 1{,}37$, the Sun's altitude being 70°

According to the theory of the instrument we may write

$$Q = \frac{r\, i^2}{4{,}19 \times b \times a} \times 60 = C i^2$$

where i is the observed compensating current in amperes, r the resistance per centimeter of the manganin strips in ohms, b the breadth of the strips, a their absorption power

Professor ANGSTROM — to whom I express my sincere thanks for his interest and assistance — had kindly determined the values of r, b and a before despatching the instrument, after our return home these constants were found to be nearly unaltered They are

$$\begin{aligned} b &= 0{,}1496 \text{ cm} \\ a &= 0{,}98 \\ r &= 0{,}07875 \text{ at } 20^\circ \\ \alpha &= 0{,}00045 \text{ (temp coeff of } r) \end{aligned}$$

giving

at temperatures	0°	10°	20°	30°	40°
$C =$	7,62(0)	7,65(5)	7,69(0)	7,72(5)	7,76(0)

The sensibility of our milliammeter of SIEMENS & HALSKE had to be reduced by a shunt, so that the pyrheliometer current i was found by multiplying the observed current i by the reductionfactor 3,97

It would be useless to give a full account of all the absolute measurements made during our stay in the camp, as the sky conditions were most times unfavourable for the purpose The following table, therefore contains only some data obtained on May 6th in order to show the fluctuations of the radiation even on a clear day, and further the few observations which it was possible to make on the morning of the eclipse at tolerably clear moments

TABLE II

Time	Temperature inside pyrheliometer	Zero reading of galvanometer	Current i observed when exposing one of the strips			Zero reading of galvanometer
May 6			left	right	left	
$10^h\ 10^m$	34,°7	11,7	100,6	98,9	100,0	11,7
11 50	35, 1	10 1	101,2	99,0	100,2	10,1
12 45	35, 7	10,1	100,2	100,5	100,8	10,1
2 30	36	7,5	97,5	95,0	100,0	7,4
May 18						
10 10	33, 5	6,8	65,3	60	48,5	7,0
10 40	35, 7	7,1	91,6	100	99,5	7 1
10 45	35, 5	7,0	101	101	101	7,0
10 48	35, 2	7,0	97,8	95	90,5	7,0
10 55	34, 5	7,1	79	88,2	91,8	7,1
11 3	34, 2	7,05	75	72 2	69,8	7,1
11 15	34, 3	7,1	63,2	61,2	62,9	7,1

To the current $i' = 101$ milliampères which was observed at $10^h\ 45^m$, shortly before first contact, corresponds the compensating current

$$i = 0{,}101 \times 3\ 97 = 0{,}401 \text{ ampère},$$

at temperature 35,5° we have $C = 7{,}74$, hence

$$Q = Ci^2 = 1{,}245$$

UTRECHT, June 1905

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